Marion J. Jackson

Digitized by the Internet Archive
in 2012 with funding from
LYRASIS Members and Sloan Foundation

http://archive.org/details/proceedingsofin741964indi

PROCEEDINGS

of the

Indiana Academy of Science

Founded December 29, 1885

•

Volume 74

1964

•

RICHARD A. LAUBENGAYER, Editor
Wabash College
Crawfordsville, Indiana

•

Spring Meeting
May 8-9
McCormick's Creek State Park

Fall Meeting
October 29-31
INDIANA CENTRAL COLLEGE

Published at Indianapolis, Indiana
1965

1. The permanent address of the Academy is the Indiana State Library, 140 N. Senate Ave., Indianapolis 4, Indiana.

2. **Instructions for Authors** appear at the end of this volume, P. 403.

3. **Exchanges.** Items sent in exchange for the Proceedings and correspondence concerning exchange arrangements should be addressed:

John Shepard Wright Memorial Library of the Indiana Academy of Science
c/o Indiana State Library
Indianapolis, Indiana 46204

4. **Proceedings** may be purchased through the State Library at $5.00 per volume.

5. **Reprints of technical papers** can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

6. The Constitution and By-Laws reprinted from v. 74 are available to members upon application to the Secretary. Necrologies reprinted from the various volumes can be supplied relatives and friends of deceased members by the Secretary.

7. Officers whose names and addresses are not known to correspondents may be addressed care of the State Library.

Papers published in the Proceedings of the Indiana Academy of Science are abstracted or indexed in appropriate services listed here:

Annotated Bibliography of Economic Geology

Bibliography of Agriculture

Bibliography of North American Geology

Biological Abstracts

Chemical Abstracts

Chemisches Zentralblatt

Current Geographical Publications

Geological Abstracts

Mathematics Reviews

Metallurgical Abstracts

Psychological Abstracts

Review of Applied Entomology

The Torrey Bulletin

Zoological Record

TABLE OF CONTENTS

Page

Officers and Committees for 1964 6
Minutes 11
Revised Constitution and By-Laws 21
New Members, 1964 30
Junior Academy of Science 33
Necrology 41
Presidential Address 60

Anthropology

A. L. URBONT—The sacrum of the American Indian 68
J. K. SMAIL—The use of female crania in demonstrating racial relationships in two Upper Mississippi Amerind groups 72
K. B. HUNTER—Preliminary report on the Hopewellian skeletons from the Klunk site, Calhoun County, Illinois 81
FLORENCE H. CHAPMAN—Comparison of osteoarthritis in three aboriginal populations 84
H. W. NEUMANN—A preliminary study in the paleopathology of an archaic American Indian population 87
G. K. NEUMANN and C. H. TOMAK—The Early Woodland manifestation in Greene County, Indiana 90
W. R. HURT—Climatic change and the Northern Plains Archaic 90
E. O. SEGAL—Some institutional response to culture contact 107
J. A. FRISCH—The social organization of the Northeastern Algonkians 112
B. K. SWARTZ, JR.—A suggested standardization of nomenclature in archaeological methodology 114

Bacteriology

Abstracts of papers not published in full 118
B. S. WOSTMANN and G. B. OLSON—The effect of the successive administration of two antigens to germfree and conventional chickens 120
G. B. OLSON and B. S. WOSTMANN—Lymphocytopoiesis and plasmacytopoiesis in germfree mice stimulated with 7s human gamma globulin 125
H. M. POWELL—Inhibitory action of statolon against polyoma virus 132
H. M. POWELL—Mouse tests of poliomyelitis vaccine 136
P. L. SMITH and R. J. GREEN, JR.—Identification and physiological studies of soil bacteria causing fungistasis 140
C. R. HASSLER and R. I. FLETCHER—Aerobic heavy sludge digestion 149

Botany

Abstracts of papers not published in full 152
HENRY SHANDS, F. L. PATTERSON and J. F. SCHAFER—Inheritance of resistance to loose smut in three winter barleys 155
W. R. EBERLY—Preliminary results in the laboratory culture of planktonic blue-green algae 165
A. A. LINDSEY and D. V. SCHMELZ—Comparison of Donaldson's Woods in 1964 with its 1954 forest map of 20 acres 169

Chemistry

Page

Abstracts of papers not published in full 178
P. LUDWIG, J. D'ALLESSIO and M. BURTON—Generation and measurement of μv light pulse in the nanosecond and sub-nanosecond region 181
D. J. COOK and W. E. SCHELWALT—The preparation of several 3, 4-dialkylyuinolines and intermediate compounds 183
T. C. SCHWAN—Some problems encountered in copolymerization studies using Ziegler-Natta type catalysts 189

Entomology

Abstracts of papers not published in full 194
LELAND CHANDLER—The social wasps in Indiana (Hymenoptera: Vespidae) 197
WALTER BRIGADIER and GERTRUDE L. WARD—Protura of Wayne County, Indiana 205
J. V. OSMUN and R. A. BRAM—Insects and other Arthropods of economic importance in Indiana in 1964 207
M. L. CLEVELAND—Maintenance of fruit insect cultures at Vincennes, Indiana 219

Geology and Geography

Abstracts of papers not published in full 222
J. F. HART—Population concentration in Indiana 224
S. S. Visher—Is Indiana becoming overpopulated? 230
A. H. MEYER and BEN LAIR—Manufactural geography of Greater Blue Island, Illinois 232
J. C. HOOK and A. J. CANTIN—A comparison of ten, twenty-five and fifty year climatic records 245
A F. SCHNEIDER—Noncongressional land-survey divisions in Indiana 248
LEE GUERNSEY—Strip coal mine reclamation problems in Indiana .. 255
T. R. WEST and D. J. BARR—Economic groundwater problems encountered in the development of a housing area 259
C. L. BIEBER—Structural mapping by means of Mississippian corals in West-Central Indiana 268
J. H. CLEVELAND—Variation of Iron sulfide content in sphalerites of Mississippi valley deposits 271
E. B. HESS—Historical background—Wisconsin population, population distribution 278

History of Science

Abstracts of papers not published in full 283
R. E. GIRTON—Three-quarters of a century of biology at Purdue University: 1874-1947 284
BENJAMIN MOULTON—Charles Redway Dryer 289

Physics

D. H. ALMAN and H. K. HUGHES—Fourier synthesis 294

Page

C. F. HACKETT and H. K. HUGHES—A constant speed drive for Mossbauer experiments 298
J. F. HOULIHAN—Energy ether 302

Plant Taxonomy

Abstracts of papers not published in full 307
R. O. PETTY—Forest analysis of a mesic ravine, Parke County, Indiana 308
G. C. Marks—Castilleja coccinea in the yellow form 314
SUE E. HARPER and C. E. GIFFORD—A twice taken sampling of phytoplankton in four areas of Dewart Lake, Indiana 315

Soil Science

R. K. STIVERS—Some characteristics of Purdue soil testing data from field plots 319
ROBERT MONTGOMERY and K. A. WENNER—Soil survey saves Lake County taxpayers' money 325
J. M. ROBBINS, JR.—Soil associations of Perry County 328
C. W. GUERNSEY—Characteristics and formation of plinthite on Maui Island, Hawaii 335
P L. ZIEMER and J. E. CHRISTIAN—Determination of the gross gamma radioactivity of Indiana soils by large volume liquid scintillation counting 339
P. L. ZIEMER, L. A. SCHAAL, J. E. NEWMAN, C. L. RHYKERD, and J. E. CHRISTIAN—Gross gamma radioactivity in Indiana precipitation 343

Zoology

Abstracts of papers not published in full 348
J. R. GAMMON—The distribution of fishes in Putnam County, Indiana, and vicinity 353
J. H. HAMON—Another cat with an "upside-down" stomach 360
W. C. GUNTHER—Further observations on effect of nonoptimally high incubation temperature on frequency of pecking and color preference in the chick 362
W. C. CLARK—Vitamin deficiency and survival of Hepatoma BW7756 mice 367
SUSAN E. WADE and C. E. GIFFORD—The turtle population of a Northern Indiana Lake 371
A. E. REYNOLDS and T. A. STABLER—Quantitative external relationships in two species of small plethodons 375
J. M. PHELPS, JR., J. R. HASTINGS and J. E GAMMON—The effect of pesticides on the Bluegill (Lepomis macrochirus) 379
D. M. O'BRIAN, C. YABLONSKY and C. GILLOLY—The effects of parental age on egg production, hatchability of the eggs, and survival of the offspring in Drosophila melanogaster 386
RUTH E. PETTEE and C. E. GIFFORD—The distribution of macroinvertebrates in littoral macrophytes in an Indiana lake 393
HAROLD EDDLEMAN—Scar: a temperature sensitive mutation in Tribolium castaneum Herbst 398

Officers and Committees

Officers for 1964

President	Edward L. Haenisch, Wabash College
Vice President	Frank J. Welcher, Indiana University
Secretary	Clarence F. Dineen, St. Mary's College
Membership Secretary	Carrolle A. Markle, Earlham College
Treasurer	James C. List, Ball State Teachers College
Editor	Richard A. Laubengayer, Wabash College
Press Secretary	Frank N. Young, Indiana University

Chairmen Elected by the Divisions

Anthropology	Wesley Hurt, Indiana University Museum
Bacteriology	Robert Deufel, Indiana Central College
Botany	P. A. Orpurt, Manchester College
Chemistry	Q. R. Petersen, Wabash College
Entomology	Merrill Cleveland, 118 Chestnut Street, Vincennes, Indiana
Geology and Geography	J. F. Hart, Indiana University
History of Science	A. T. Guard, Purdue University
Mathematics (Acting)	R. M. Brooker, Indiana Central College
Physics	K. Kolitschew, Indiana Central College
Plant Taxonomy	R. Petty, Wabash College
Psychology (Acting)	R. M. Brooker, Indiana Central College
Soil Science	J. M. Robbins, 1727 14th Street, Tell City, Ind.
Zoology	R. H. Cooper, Ball State Teachers College

Executive Committee

(Past Presidents*, Current Officers, Divisional Chairmen, Committee Chairmen)

*Baldinger, L. H.
Brooker, R. M.
Carlson, K. H.
*Christy, O. B.
*Cleland, R. F.
Cleveland, M.
Coats, Nelle
Cooper, R. H.
*Daily, W. A.
*Davis, J. J.
*Day, H. G.
*Degering, E. F.
DeLanney, L. E.
Deufel, Robert
Dineen, C. F.
*Edington, W. E.
*Edwards, P. D.
*Girton, R. E.
*Guard, A. T.
Haenisch, E. L.
Hart, J. F.
Heniser, Virgil
Hurt, W.
*Johnson, W. H.
Kaufman, Karl
Kessel, W. G.
Klinge, P.
Kolitschew, C.
Laubengayer, R. A.
*Lilly, Eli
List, J. C.
McCoy, Scott
*Mackell, J. F.
Markle, C. A.
*Markle, M. S.
*Mellon, M. G.
*Meyer. A .H.
*Michaud, H. H.
Miller, G. R.
*Morgan, W. P.
Orpurt, P. A.
Overmire, T.
Petersen, Q. R.
Petty, R.
*Porter, C. L.
*Powell, H. M.
Robbins, J. M.
Seymour, K.
*Visher, S. S.
*Wallace, F. N.
*Weatherwax, P.
Webster, J. D.
*Welch, W. M.
Welcher, F. J.
Young, F. N.
Youse, H.

BUDGET COMMITTEE

Consisting of: President (Haenisch), President-Elect (Welcher), Secretary (Dineen), Membership Secretary (C. Markle), Treasurer (List), Editor (Laubengayer), Sponsor of Junior Academy (Overmire), Library Committee (Coats), Program Committee (Brooker), and Relation of Academy to State (Daily). Invited participants: Retiring President (Michaud), Retiring Secretary (Bloom), Retiring Treasurer (Carlson), Youth Activities Committee (Klinge and Heniser).

COMMITTEES ELECTED BY THE ACADEMY

Trustees of the Academy Foundation: Chairman W. P. Morgan, Indiana Central College (term expires 1964); William A. Daily, Lilly Company (1965).

Bonding Trustees (elected yearly): Chairman, Scott McCoy, Technical High School, Indianapolis; D. J. Cook, DePauw University.

Research Grants (term 5 years): Chairman, P. Weatherwax, Indiana University (1966); K. M. Seymour, Butler University (1965); A. A. Lindsey, Purdue University (1968); J. F. Hart, Indiana University (1967); Edward L. Haenisch and C. F. Dineen, ex officio. (Vacancy expiring 1964—death of T. G. Yuncker.)

COMMITTEES APPOINTED BY THE PRESIDENT

(President an ex officio member of all committees)

Auditing Committee: Chairman, K. H. Carlson, Valparaiso University; W. W. Bloom, Valparaiso University.

Biological Survey: Chairman, J. D. Webster, Hanover College; R. H. Cooper, Ball State College; F. K. Daily, Butler University; C. J. Goodnight, Purdue University; Mrs. D. G. Graam, Commercial Solvents Corporation; C. Markle, Earlham College; H. H. Michaud, Purdue University; W. H. Welch, DePauw University; F. N. Young, Indiana University.

Fellows (Committee appointed in terms of change in constitution): Chairman, K. M. Seymour, Butler University; **Anthropology:** H. E. Driver, Indiana University (1966); **Bacteriology:** L. S. McClung, Indiana University (1966); **Botany:** W. H. Welch, DePauw University (1966); **Chemistry:** K. M. Seymour (1966); **Entomology:** L. Chandler, Purdue University (1966); **Geology and Geography:** F. Hurlburt, Anderson College (1965); **History of Science:** G. F. Hennion, University of Notre Dame (1965); **Mathematics;** J. C. Polley, Wabash College (1965); **Physics:** C. S. Morris, Manchester College (1965); **Plant Taxonomy:** A. T. Guard, Purdue University (1965); **Psychology:** E. J. Asher, Purdue University (1964); **Soil Science:** A. R. Bertrand, Purdue University (1965); **Zoology:** Murvel Garner, Earlham College (1964).

Index: Chairman, R. A. Laubengayer, Wabash College; Nelle Coats and Mrs. Lois Burton, Indiana State Library.

Invitations: Chairman, Glen R. Miller, Goshen College; G. D. Lovell, Wabash College; W. P. Morgan, Indiana Central College; F. D. Rossini, University of Notre Dame.

Library: Chairman, Nelle Coats, Indiana State Library; G. A. Black, Indiana University; Mrs. Lois Burton, Indiana State Library; Eli Lilly, Eli Lilly and Company.

Membership: Chairman, L. E. DeLanney, Wabash College; J. Barton III, St. Joseph's College; G. H. Bick, St. Mary's College; C. L. Bieber, DePauw University; M. Alan Brown, Franklin College; R. Coleman, Evansville College; J. Cope, Earlham College; J. H. Danehy, University of Notre Dame; H. M. Dixon, Butler University; W. E. Eberly, Manchester College; W. C. Gunther, Valparaiso University; Aubrey Larsen, Mead Johnson and Company; M. E. Hodson, Marion College; W. P. Hopp, Indiana State College; R. Howard, Oakland City College; R. Kent, Indiana Central College; G. M. Krueger, Taylor University; D. E. LeMaster, Huntington College; N. O. Long; Indiana Technical College; Mrs. M. J. Mayo, Anderson College; G. R. Miller, Goshen College; F. L. Murphy, Vincennes University; J. J. Nisbet, Ball State College; S. N. Postlethwait, Purdue University; H. M. Powell, Indiana University (Medical Center); Sr. M. Rose, Marion College; J. D. Webster, Hanover College; F. J. Zeller, Indiana University (Bloomington campus).

Necrologists: W. E. Edington, DePauw University; W. H. Welch, DePauw University.

Program: Chairman, Robert M. Brooker, Indiana Central College; Honorary Chairman, William P. Morgan, Indiana Central College; Robert Deufel, Indiana Central College; Max Stark, Eli Lilly Company; James Hayden, Pitman-Moore.

Publication of Proceedings: Chairman, Richard A. Laubengayer, Wabash College; J. A. Clark, State Department of Conservation; A. A. Lindsey, Purdue University.

Publicity: Chairman, F. N. Young, Indiana University; Nelle Coats, Indiana State Library; R. L. Henry, Wabash College; L. E. Weller, Evansville College.

Relation of Academy to State: Chairman, William A. Daily, Eli Lilly and Company; J. A. Clark, Department of Conservation; Eli Lilly, Eli Lilly and Company; Richard A. Laubengayer, Wabash College; Clarence F. Dineen, St. Mary's College, ex officio.

Representative on Council of the A.A.A.S.: W. H. Johnson, Wabash College.

Resolutions: Chairman, Howard Youse, DePauw University; Shelby Gerking, Indiana University; Lawrence Baldinger, University of Notre Dame.

Special Constitution Revision Committee: Chairman, Paul Weatherwax, Indiana University and Franklin College; R. H. Cooper, Ball State College; William A. Daily, Eli Lilly and Company; H. G. Day, Indiana University; Ray T. Everly, Purdue University; H. H. Michaud, Purdue University; ex officio: Edward L. Haenisch, Wabash College.

Special Committee on Finance: Chairman, W. A. Daily, Eli Lilly and Company; R. A. Laubengayer, Wabash College; ex officio: E. L. Haenisch, Wabash College.

Youth Activities Committee: Chairman, Paul Klinge, Indiana University; Vice-Chairman, Virgil Heniser, Indiana University; Otto Behrens, Eli Lilly Company; Robert Brooker, Indiana Central College; Kermit Carlson, Valparaiso University; Robert H. Cooper, Ball State College; Mrs. Elizabeth Crider, Washington High School, Indianapolis; Sears Crowell, Indiana University; Harry G. Day, Indiana University; Herschell Dassell, Evansville Public Schools, Evansville; Willis Johnson, Wabash College; Karl Kaufman, Butler University; Robert Kent, Title III Office, State House, Indianapolis; R. W. Lefler, Purdue University; Howard Michaud, Purdue University; Thomas Overmire, Ball State College.

Woodrow Pemberton, Bosse High School, Evansville; Lawrence Poorman, University High School, Bloomington; Mrs. Marion Rector, 104 Riley Road, Muncie; William Smith, Howe High School, Indianapolis; Erwin Steinkamp, New Albany High School, New Albany; L. A. Willis, Tri-State College, Angola; Miss Ruth Wimmer, Elmhurst High School, Fort Wayne; ex officio, Edward L. Haenisch, F. J. Welcher, J. C. List.

Indiana Junior Academy of Science: State Sponsor, Thomas Overmire, 1523 Norfolk, Falls Church, Va.; Council, Don R. Winslow, University High School, Bloomington; Miss Helen Reed, Manual High School, Indianapolis; Erwin Steinkamp, New Albany High School, New Albany; Sr. Marian Francis, Reitz Memorial High School, Evansville; Keith Hunning, New Haven High School, New Haven.

Indiana Science Talent Search: Director, Virgil Heniser, Indiana University; committee: L. H. Baldinger, University of Notre Dame; Sears Crowell, Indiana University; Harold Garner, Purdue University; Clinton Gass, DePauw University; Robert Henry, Wabash College.

Indiana Science Fairs: State Coordinator, K. L. Kaufman, Butler University; Regional Directors: P. V. Flannery, Purdue University Calumet Center, Hammond **(Calumet Regional)**; A. C. Koester, Valparaiso University **(Northwestern Indiana Regional)**; H. R. Weimer, Manchester College **(Northern Indiana Regional)**; W. W. Hill, Jr., Tri-State College, Angola **(Northeastern Tri-State Regional)**; R. L. Ewigleben, Purdue University, Fort Wayne Center **(Northeastern Indiana Regional)**; C. E. Hess, Purdue University **(Lafayette Regional)**; R. W. Neithamer, Rose Polytechnic Institute, Terre Haute **(West Central Indiana Regional)**; G. E. Doeden, Ball State College **(East Central Indiana Regional)**; M. H. Weinswig, Butler University **(Central Indiana Regional)**; Virgil Heniser, Indiana University **(South Central Indiana Regional)**; Brian Hill, Indiana University Center, Jeffersonville **(Southeastern Indiana Regional)**; P. W. Hartmen, Evansville College **(Tri-State Regional)**.

Visiting Scientists: Chairman, William G. Kessel, Indiana State College; K. H. Carlson, Valparaiso University; Robert H. Cooper, Ball State College; Mrs. Elizabeth Crider, Washington High School, Indianapolis; Ernest Litweiler, John Adams High School, South Bend.

SPRING MEETING

MINUTES OF THE EXECUTIVE COMMITTEE MEETING

McCormick's Creek State Park

May 8, 1964

President Edward L. Haenisch called the Executive Committee Meeting to order at 4:30 p.m. Twenty-five members attended the meeting.

The treasurer James C. List submitted the financial report for the period January 1, 1964 to May 1, 1964. The balance of the State accounts was $7,510.12. The National Science Foundation Grant balance was $4,876.97. Thus making a total balance in all Academy accounts of $12,387.09. The treasurer's report was accepted.

Editor Richard A. Laubengayer reported that the galley proofs would be sent to the authors on May 11. He requested a rapid return of the proofs for final printing.

The program chairman, Robert M. Brooker, stated that the plans for the fall meeting at Indiana Central College, Indianapolis, Indiana, were progressing very well.

President Edward L. Haenisch read a formal invitation from Reverend Theodore M. Hesburgh, President of the University of Notre Dame, to have the Academy hold the 1965 fall meeting at the University of Notre Dame. The invitation was accepted. Invitations have already been received for the 1966 meeting.

The chairman of the Special Constitution Revision Committee, Paul Weatherwax, stated that the members have worked diligently on the proposed revision of the Constitution and By-Laws. The revision is to be printed and distributed to the members at least two months before the fall meeting. The proposed revision will be placed on the agenda for the fall meeting. Dr. Weatherwax requested comments and suggestions for the revision. The election of officers and the nomination committee sections of the Constitution and By-Laws were discussed briefly.

The sponsor of the Indiana Junior Academy of Science, Thomas Overmire, asked to be relieved of this assignment. Necessary committee action to obtain a replacement was planned.

Dean Karl Kaufman, state coordinator of the Indiana Science Fairs, is planning to reorganize the committee of directors.

No major change is expected in the National Science Foundation support of the Visiting Science Program. Necessary action will be taken by the chairman, Willliam G. Kessel, for directing this program for the academic year 1964-1965. President Elect, Frank J. Welcher attended a meeting in Washington, D.C. pertaining to this program

Clarence F. Dineen, Secretary

Approved October 29, 1964

SPRING MEETING
MINUTES OF THE GENERAL SESSION

McCormick's Creek State Park

May 8, 1964

Following the dinner in the main dining room of the Inn, the formal business session was called to order by the President, Edward L. Haenisch, at 8:00 p.m. President Haenisch welcomed the members and introduced the current officers and the divisional chairmen present.

The membership secretary, Carrolle A. Markle, reported that eleven applications for membership had been received. The applications were approved.

E. E. Kenaga, entomologist, Dow Chemical Company, Midland, Michigan, and immediate past-president of the Michigan Audubon Society presented an excellent illustrated address entitled "Birding in Michigan." About 125 attended the address.

The program chairman, Robert M. Brooker, introduced the leaders of the field trips for Saturday morning. The bird hike was planned by Dr. J. Hill, the botany trip by Dr. Joe Hennen, the geology trip by Drs. John Cleveland and Samuel Smith, and the zoology trip by Dr. Clarence Goodnight.

The following resolution was prepared by Howard R. Youse: "The Indiana Academy of Science would like to express their appreciation to Mr. Merle Richardson, manager of Canyon Inn, and his staff for all the arrangements for this spring meeting. The Academy also extends its thanks to the program chairman, speakers, and leaders of the field trips for their services." The meeting adjourned.

Clarence F. Dineen, Secretary

Approved October 29, 1964

MINUTES OF THE EXECUTIVE COMMITTEE MEETING

INDIANA CENTRAL COLLEGE, INDIANAPOLIS, INDIANA

October 29, 1964

The Executive Committee of the eightieth session was called to order by President Edward L. Haenisch at 7:30 p.m. Thirty-four members were present.

The minutes of the Spring meeting of the Executive Committee and the General Session of the Academy held at McCormick's Creek State Park were read and approved.

Treasurer—Dr. James C. List: A summary of the financial report from January 1, 1964, through September 30, 1964, is as follows:

In the total State accounts: a balance of $5,488.71 on January 1; receipts, $14,572.68; disbursed $10,878.13; a balance of $9,183.26 on September 30, 1964.

In the National Science Foundation Fund (G. E. 1846); a balance of $3,593.83 on January 1, 1964; receipts $8,751.11; disbursed, $9,711.67; a balance of $2,633.27 on September 30, 1964.

FINANCIAL REPORT OF THE INDIANA ACADEMY OF SCIENCE

January 1, 1964 through December 31, 1964

	Balance Jan. 1, 1964	Receipts	Disbursed	Balance Dec. 31, 1964
1. Indiana Academy of Science (Budgeted)	$ 2,269.49	$ 5,970.84	$ 7,451.53	$ 788.80
2. Junior Academy	8.46	50.00	46.16	12.30
3. Academy Funds for Research	1,200.00	1,102.00	1,500.00	802.00
4. J. S. Wright Mem. Lib. Lilly Endowment	745.81		23.86	721.95
5. Science Fair	191.62	7,220.00	4,309.22	3,102.40
6. Science Talent Search	1,073.33	2,000.00	1,261.95	1,811.38
Total in State Accounts	5,488.71	16,342.84	14,592.72	7,238.83
N.S.F. Grant G E 1846	3,593.83	8,751.11	12,344.94	
N.S.F. Grant G E 4306		8,680.67	4,186.73	4,493.94
Total in all Indiana Academy Accounts	$ 9,082.54	$33,774.62	$31,124.39	$11,732.77

Bank Balances, American National Bank and Trust Company, Muncie, Indiana:

Checking	$ 2,896.75
Savings	8,836.02
	$11,732.77

James C. List, Treasurer
December 31, 1964

We, the undersigned, have examined the accounts of the Indiana Academy of Science for 1964 and have found them to be accurate and in order.

Auditing committee
Kermit H. Carlson
William W. Bloom

Trustees of the Academy Foundation—William A. Daily, Chairman: The Academy Fund from October 1, 1963, to September 30, 1964, had a beginning balance of $848.78; total receipts $731.56; total disbursement $768.30; an ending cash balance of $812.04. The total carrying value was $16,036.15. The John S. Wright Fund (March 1, 1964) had total receipts of $3,814.89; total disbursement of $467.74; and a cash balance of $3,347.15. The total carrying value was $241,609.28. The report was approved.

Bonding Trustees—Scott McCoy: The bond covering the Treasurer and the Trustees of the Academy was reported in good order. The bonding expires on November 18, 1965. The renewal cost is approximately $62.50. The amount of the bonding was discussed. A motion was approved to maintain the bonding at the present level.

Research Grants—Dr. Paul Weatherwax, Chairman: Dr. Weatherwax has been appointed Chairman of this committee by the President after the death of Dr. Truman Yuncker. To date, several applications were received and evaluated. The committee is preparing a statement of policy with regard to grants and a procedure for making application.

Special Constitution Revision Committee—Dr. Paul Weatherwax, Chairman: The committee completed the proposed Constitution and By-Laws. Copies were mailed to the membership of The Academy more than two months prior to the date of this meeting. A clerical error was corrected in the list of recognized subject matter sections (Art. IV, Sec. 4), that is, the designation of *Taxonomy* was changed to *Plant Taxonomy*.

Several sections of the proposed Constitution and By-Laws were discussed. A desire to include student membership was expressed. The chairman of the committee moved that the proposed Constitution and By-Laws be approved and submitted to The Academy for adoption. The motion was carried.

Biological Survey—Dr. J. D. Webster, Chairman. The list of publications for 1963-1964 is as follows:

Algae:

Dailey, W. A., and R. T. Everly. 1964. Algae found growing in plastic enclosures covering ears of popcorn plants. Proc. Ind. Acad. Sci. for 1963. **73**:219.

Harper, Sue. 1965. A qualitative and quantitative sampling of two days of phytoplankton in four areas of Dewart Lake, Indiana. Proc. Ind. Acad. Sci. for 1964. **74**: In press.

Lipscomb, R. G., 1964. A study of the winter diatom (Bacilliariophyciae) flora in Fall Creek, Indiana. Butler Univ. Botanical Studies. **14**(2):41-52.

Vascular Plants:

Crankshaw, W. B., A. A. Lindsey, and S. A. Qadir, 1965. Edaphic Controls of Tree Species in Presettlement Indiana. Ecology: in press.

Hall, G. W., 1963. Notes on the comparative biology of the Eastern North American species of Bidens. Proc. Ind. Acad. Sci. for 1962. **72**:256.

Lindsey, A. A., W. B. Crankshaw, and S. A. Qadir, 1965. Soil Relations and Distribution Map of the Forests of Presettlement Indiana. Botanical Gazette: In press.

Lindsey, A. A., and D. V. Schmelz, 1965. Comparison of Donaldson's Woods in 1964 with its 1954 forest map. Proc. Ind. Acad. Sci. for 1964. **74**:169-177.

Marks, G. D., 1965. The occurrence of the yellow form of **Castilleja coccinea** in Northwest Indiana. Proc. Ind. Acad. Sci. for 1964. **74**: In press.

Petty. Robert, 1965. Forest analysis of a mesic ravine, Parke County Indiana. Proc. Ind. Acad. Sci. for 1964. **74**: In press.

Petty, Robert, and Daniel Harwood, 1964. Rush Woods, a lowland extension of the beech-maple climax, Montgomery County, Indiana. Proc. Ind. Acad. Sci. for 1963. **73**:220-226.

Schmelz, D. V. and Lindsey, A. A., 1965. Graphical analysis of the size-class structure of old-growth forests in Indiana. Proc. Ind. Acad. Sci. for 1964, **74**: In press.

Witmer, S. W., 1964. **Butomus umbellatus** L. in Indiana. Castanea, Vol. 29: 117-119.

Vascular Plants & Bryophytes:

Welch, Winona H., 1964. Truman George Yuncker. (Includes all of his publications, many pertaining to Indiana Flora.) Bull. Torrey Bot. Club, **91**(5): 406-412.

Insecta:

Brigidier, Walter, and Gertrude L. Ward, 1965. Protura of Wayne County, Indiana. Proc. Ind. Acad. Sci. for 1964. **74**. In press.

Chandler, Leland, 1963. Interspecific competition between two species of **Osmia** (Hymenoptera, Megachilidae). Proc. North Central Branch, Entomol. Sec. Amer **18**: 50.

Chandler, Leland, 1965. The social wasps in Indiana (Hymenoptera, Vespidae). Proc. Ind. Acad. Sci. for 1964. Vol. **74**. In press.

Siverly, R. E., 1963. Occurrence of **Aedes excrucians** (Walker) in Indiana. Proc. of the Indiana Academy of Science for 1962. **72**: 40.

Siverly, R. E, and R. W. Burkhardt, Jr. 1965. Occurrence of **Psorophora discolor** (Coquillet) in Indiana. Proc. Ind. Acad. Sci. for 1964. **74**: In press.

Invertebrates (general):

Pettee, Ruth E., and C. E. Gifford, 1965. The distribution of macro-invertebrates and macrophytes in a Northern Indiana lake. Proc. Ind. Acad. Sci. for 1964. **74**: In press.

Pisces:

Gammon, J. R., 1965. The distribution of fishes in Putnam County, Indiana and vicinity. Proc. Ind. Acad. Sci. for 1964. **74**: In press.

Hatcher, V. O., and J. R. Gammon, 1965. A preliminary study of a littoral fish population in a Northern Indiana lake. Proc. Ind. Acad. Sci. for 1964. **74**: In press.

Reptilia:

Wade, Susan E., and C. E. Gifford, 1965. A preliminary study of the turtle population of a Northern Indiana lake. Proc. Ind. Acad. Sci. for 1964. **74**: In press.

Aves:

Hamon, J. H., 1965. Bird eggs in the Gorby collection. Proc. Ind. Acad. Sci. for 1964. **74**: In press.

Indiana Audubon Society members, 1963-64. Many titles in Indiana Audubon Quarterly, Vol. **41**, 1963 and Vol. **42**, 1964.

Baker, Mrs. H. A., 1963. Breeding bird census No. 27. Grazed, brushy fields and tree-bordered creek. Aud. Field Notes, **17** (6): 505.

Mumford, R. S., and Rowe, W. S., 1963. The Lesser Black-backed Gull in Indiana. Wilson Bull. **75**(1): 93.

Sintz, J. K., 1963. Winter bird population study No. 12, Abandoned fields dominated bl broomsedg. Aud. Field Notes, **17**(3): 368-369.

Webster, J. D., **et al.**, 1963. Winter bird population study No. 8, Beech-maple Forest. Aud. Field Notes, **17**(3): 367.

Webster, J. D., 1963. Breeding bird census No. 8, Tornado-disturbed beech-maple forest. Aud. Field Notes, **17**(6): 496-497.

Mammalia:

Humphrey, Stephen, and J. B. Cope, 1964. Movements of **Myotis lucifugus lucifugus** from a colony in Boone County, Indiana. Proc. Ind. Acad. Sci. for 1963. **73**: 268-271.

Mumford, R. E. and J. B. Cope, 1964. Distribution and status of the Chiroptera of Indiana. Amer. Midland Nat. **72**: 473-489.

Theses completed and placed on file, dealing with the Flora and Fauna of Indiana

Bryophytes:

Lantz, L. A., 1963. Acrogynous Jungermanniales: A taxonomic treatment of the species occurring in Indiana. M.A. Thesis, DePauw.

Vascular Plants:

Crankshaw, W. B., 1964. Edaphology of tree species in presettlement Indiana south of the Late Wisconsin glacial border. Ph.D. thesis, Purdue.

Jackson, M. T., 1964. Microclimatic differences and their effects on spring flowering phenology. Ph.D. thesis, Purdue.

Mann, R. K., 1964. A taxonomic study of the species of woody **Smilax** in Indiana. M.S. thesis, Purdue.

Miller, Lillian W., 1964. A taxonomic study of the species of **Acalypha** in the United States. Ph.D. thesis, Purdue.

Milstead, W. L., 1964. A revision of the North American species of **Prenanthes**. Ph.D. thesis, Purdue.

Qadir, S. A., 1964. A study of edaphic controls of tree species in presettlement forests of northern Indiana. Ph.D. thesis, Purdue.

Schmelz, D. V., 1964. A graphical analysis of the size-class structure of Indiana forests. M.S. thesis, Purdue.

Insecta:

Burton, J. S., 1964. The species of **Chrysops** (Diptera: Tabanidae) in Indiana. M.S. thesis, Purdue.

Grothaus, R. H., 1962. The biology of the species of **Ceratina** in Indiana (Hymenoptera. Anthophoridae). M.S. thesis, Purdue.

Sanders, D. P., 1964. The insect complex associated with cow manure. M.E. thesis, Purdue.

Arachnida:

Cleveland, M. L., 1964. Phytophagous mites of apples in Indiana. Ph.D. thesis, Purdue.

Work in progress, but not yet published, dealing with the Flora and Fauna of Indiana

Vascular Plants:

Markle, Carrolle A., Flora of Wayne County, Indiana.
Gordon, Donald, Revision of **Gleditsia**.
Mertens, T. R., Genus **Polygonum** (sect **Polygonum**)

Crustacea:

Wise, C. D., Ostracods.
Chandler, L., Biosystematics of Indiana Bees.
——— Development of community ordination using winter stoneflies.
Giese, R. L., Climatic Release of Animal Populations.
——— Mathematical Distribution of Insects.
Hendricks, D. E., Ectoparasites and arthropod associates of the thirteen-lined ground squirrel, **Citellus tridecemlineatus.**

Insecta:

MacLean, Bonnie K., Internal parasites of bumble bees.
Kirkton, R. M., Variation of **Halictus ligatus** throughout its range. (Halictidae: Hymenoptera)
McWilliams, J. G., Population Dynamics of Mosquitos.
Munsee, J. R., Ecology of ants in strip mine areas.
Pedigo, Larry, The ecology of Collembola.
Sanders, D. P., Ecological studies of insects associated with cow manure.
Schuder, D. L., Insect pests of trees, shrubs, and turf.
Siverly, R. E. Systematics and ecology of Indiana mosquitoes.
Ward, Gertrude L., Insects of Whitewater Valley.
Wood, Gerald, Pollinators of **Cucurbita** spp.
Zimmack, Harold, A collection of immature insects of Indiana.

Arachnida:

Ward, Gertrude L., Spiders of Indiana.

Mammalia:

Cope, J. B., Bats of Indiana.

Fellows—Dr. K. M. Seymour, Chairman: A motion was approved to elect the following as fellows: Dr. Joe F. Hennen, Professor of Botany, Indiana State College; Dr. Albert E. Reynolds, Professor and Head of the Department of Zoology, DePauw University.

Editor—Richard A. Laubengayer: Twelve hundred hard bound copies and six hundred paper bound copies of the Indiana Academy Proceedings were printed.

Invitations—Dr. Glen R. Miller: The 1965 fall meeting of The Academy will be held at the University of Notre Dame. The Committee recommended: Ball State Teachers College in 1966, Wabash College in 1967, Indiana Technical College in 1968. A motion was approved to accept the recommendation of the committee.

Library—Nelle M. Coats: Two hundred paper-covered items in the John Shepard Wright Memorial Library were prepared for binding. Volume 73 of the Proceedings of the Academy has been mailed to members as a service rendered by the Indiana State Library. Forty-five new titles have been acquired and will be received regularly.

Relation of Academy to the State—William A. Daily: The committee requested an increase of $1,500.00 per annum making a total of $5,500.00 per annum for publication of the Proceedings of the Academy.

Representative on the Council of the A.A.A.S.—Dr. Willis Johnson: Dr. Johnson reported that there was no discussion of anything specifically pertaining to State Academies at the meeting of the A.A.A.S. Council in Cleveland in December, 1963.

Press Secretary—Frank N. Young: Dr. Young reported that news releases were sent out on the spring and fall meetings to wire services and state newspapers. Individual releases on some papers and local news items on many individuals presenting papers at the meeting were sent out. Press coverage was generally good.

Youth Activities Committee—Paul Klinge: A grant (U.S. Office of Education Grant) of $5,000.00 (to be paid in installments) has been made to the State Superintendent of Public Instruction for the work of this Committee. Trustees for the expenditures of this grant have been designated as: Mr. Robert Kent, State Superintendent's office; Mr. Paul Klinge, Chairman of the Youth Activities Committee; Dr. Edward Haenisch, President of The Academy.

Junior Academy—Mr. Donald Winslow: Dr. Thomas Overmire resigned as director in July 1964. President Edward Haenisch appointed Mr. Donald Winslow as director. Mr. Winslow reported that action has been taken for a regional reorganization and a complete revision of the annual program of the Junior Academy of Science.

Indiana Science Talent Search—Virgil Heniser: Virgil Heniser, who was named director in the fall of 1963, reported that the continued financial support of the Tri Kappa Sorority has assured another year of operation. Mrs. Marian Rector of Tri Kappa has been named as their representative.

Science Fair—K. L. Kaufman: Virgil Heniser read the report submitted by K. L. Kaufman, State Coordinator. The 1963-1964 program was very successful. The committee members have studied means of obtaining finances for the activities.

Visiting Scientist Program—William G. Kessel: The fifth consecutive successful year of this program for Indiana high schools was conducted during the past academic year, 1963-1964. Seventy-nine scientists from twenty-three colleges and universities and three industries participated in this program. Requests for 223 visits were approved, 190 of these were completed. Better communications with high schools is being planned.

Emeritus membership status approved for: Frank M. Setzler, Frederick John Allen.

After a short discussion of the possibility of scheduling the fall meeting of The Academy on Saturday, a motion was passed which requested that the incoming President appoint an ad hoc committee to study the problem.

The meeting was adjourned at 9:25 p.m.

CLARENCE F. DINEEN, Secretary

Approved October 30, 1964

MINUTES OF THE GENERAL SESSION

October 30, 1964

The annual meeting of the Indiana Academy of Science was held in the Ransburg Auditorium of Indiana Central College, Indianapolis, Indiana, on October 30, 1964, at 9:00 a.m. Dr. Edward L. Haenisch, President, called the meeting to order. Dr. I. Lynd Esch, President of Indiana Central College, welcomed The Academy.

The minutes of the Executive meeting on Thursday, October 29, 1964, were read by the secretary and approved as read.

Dr. Winona Welch, in the absence of Dr. Will E. Edington, read a biographical sketch of members who had died since the 1963 annual meeting. These sketches are printed under Necrology in the Proceedings of the Indiana Academy of Science.

Dr. Paul Weatherwax, chairman of the Special Constitution Revision Committee, reviewed the actions of the committee. In accordance with the recommendation of the Executive Committee, Dr. Weatherwax moved that the proposed Constitution and By-Laws be adopted by The Academy. The motion was carried.

The President introduced Dr. Price, the main speaker at the general session. Dr. Charles C. Price, Chairman, Department of Chemistry, University of Pennsylvania, gave a stimulating and thought-provoking address entitled, "Evolution and World Order."

The service of the Air Force Materials Information Center was discussed by Dr. Ralph K. Birdwhistell.

The meeting was adjourned at 11:00 a.m.

The annual dinner meeting of The Academy was held in the College Dining Hall of Indiana Central College. Dr. Frank J. Welcher, President Elect of The Academy, presided.

Dr. L. E. DeLanney, chairman of the Membership Committee presented the applications for new membership in The Academy. The applications were approved. The membership secretary, Dr. Carrolle A. Markle, reported a gain in membership for the past year making a total Academy membership of 1040.

Dr. Howard Youse, DePauw University, presented the following resolutions to The Academy which were approved:

1) Resolved: That The Academy members here assembled express their sincere thanks to Indiana Central College through Dr. I. Lynd Esch, President of the College, for all the courtesies which have been shown The Academy during the meetings. Special appreciation and thanks are due Professor Robert Brooker and his committee in charge of the program and local arrangements for the splendid and efficient manner in which all arrangements were made, for the conduction of the business of The Academy, and for the comfort and convenience of the entire membership.

2) Resolved: That The Academy members here assembled express their sincere appreciation to Dr. Paul Weatherwax and his committee for their conscientious study and work in the preparation of the revised draft of the Constitution and By-Laws of the Academy, which was presented and adopted at this meeting.

Dr. Harry G. Day, Chairman of the nominating committee, read the names of the divisional chairmen which had been elected in the divisional meetings. They are as follows: Anthropology, King Burton Hunter, Indiana University; Bacteriology, Morris Wagner, University of Notre Dame; Botany, John F. Schafer, Purdue University; Chemistry, Kenneth Cook, Anderson College; Entomology, Gertrude L. Ward, Earlham College; Geology and Geography, John B. Patton, Indiana University; History of Science, Nelle Coats, State Library; Physics, H. K. Hughes, Indiana State College; Plant Taxonomy, Gayton C. Marks, Valparaiso University; Soil Science, Helmut Kohnke, Purdue University; Zoology, William Eberly, Manchester College.

The following slate of Officers and Committees to be elected by The Academy for 1965 was presented by Dr. Harry G. Day, the Nomination Committee chairman: President, Frank J. Welcher, Indiana University (as 1964 President-Elect accedes Presidency according to the Constitution); President-Elect Carrolle A. Markle, Earlham College; Secretary, Clarence F. Dineen, Saint Mary's College; Director of Public Relations, Frank N. Young, Indiana University; Treasurer, James C. List, Ball State Teachers College; Editor, Richard A. Laubengayer, Wabash College; Academy Foundation Committee, W. P. Morgan (1966), Indianapolis; Bonding Committee, Scott McCoy, Indianapolis, and Donald J. Cook, Greencastle; Research Grants Committee, Otto K. Behrens (1969), Indianapolis. A motion was carried to instruct the secretary to cast a unanimous ballot for the slate of officers and committee members.

President Edward L. Haenisch presented a scholarly address entitled, "Johnny and Relativity." The address is printed elsewhere in the Proceedings of the Indiana Academy of Science.

The meeting was adjourned at 9:00 p.m.

CLARENCE F. DINEEN, Secretary

INDIANA ACADEMY OF SCIENCE
CONSTITUTION AND BY-LAWS

Adopted at the Fall Meeting, 1964

Article I. NAME, PURPOSES, AND OFFICIAL PUBLICATION

Sec. 1. The Indiana Academy of Science (herein referred to as The Academy) is organized under the laws of the State of Indiana as a non-profit corporation devoted to scientific and educational purposes.

Sec. 2. The objectives of The Academy shall be to promote scientific research and the diffusion of scientific information; to encourage communication and cooperation among scientists, especially in Indiana; to prepare for publication such reports of investigation and discussion as may further the aims and objectives of The Academy as set forth in these articles; and to improve education in the sciences.

Sec. 3. Inasmuch as the State makes an annual appropriation to assist in publication, The Academy shall, upon request of appropriate officials, act through its Executive Committee as an advisory body in the direction and execution of any investigation within its province as stated. The Academy shall assume no responsibility for expenses incurred in the prosecution of any such investigation except as provided for in its annual budget.

Sec. 4. The official publication of The Academy, known as the Proceedings of the Indiana Academy of Science, insofar as it is published by the State, shall become a public document and shall be circulated by the Indiana State Library as agreed upon by the Library and the Committee on Relation of The Academy to the State.

Article II. MEMBERSHIP

Sec. 1. The membership of The Academy shall consist of: annual members, life members, emeritus members, fellows, honorary members, and clubs.

Sec. 2. **Annual Members.** Any person interested in science and in accord with the objectives of The Academy may, on proper application, accompanied by the initiation fee and dues for one year, be elected to annual membership.

Sec. 3. **Life Members.** Any annual member in good standing may, on contributing to the funds of The Academy an amount designated by the Executive Committee, become a life member and shall be entitled to all the privileges of annual membership without further payment of dues.

Sec. 4. **Emeritus Members.** Any member who, because of retirement or disability, petitions the Executive Committee, may be elected to emeritus membership. Emeritus members shall pay no dues and shall have all the privileges of annual membership.

Sec. 5. **Fellows.** Any member actively engaged in scientific work, with recognized standing in his field, who has been a member in good

standing for three years, may, on recommendation of the Committee on Fellows and approval of the Executive Committee, be elected a fellow of The Academy.

Sec. 6. **Honorary Members.** On recommendation of the Executive Committee, The Academy may, in exceptional instances elect honorary members. Honorary membership shall be reserved for persons who, by thei efforts, influence, or contribution to science, have rendered distinctive and meritorious service to The Academy.

Sec. 7. **Clubs.** Any science club operating in connection with a junior or senior high school in the State, may, on recommendation of the Director of the Junior Academy of Science and approval of the Executive Committee, be elected a member of The Academy. The initiation fee and dues of each club shall be determined by the Executive Committee. The individual members of such affiliated clubs shall constitute the Junior Academy of Science.

Article III. OFFICERS

Sec. 1. The officers of The Academy shall be: President, President-Elect, Secretary, Treasurer, Director of Public Relations, and Editor.

Sec. 2. The term of office of the President and President-Elect shall be one year. They shall not be eligible for reelection. The terms of the other officers shall be three years, and they may be reelected. Each officer shall continue to hold office until his successor has been duly elected and qualified.

Sec. 3. **Election of Officers.** Officers shall be elected at the annual fall meeting, and each shall assume his duties on January 1 of the following year. For the election of officers, the Committee on Nominations shall submit to The Academy nominations for the offices at that time becoming vacant. Additional nominations may be made from the floor. Election shall be by majority vote of the members present and voting.

Sec. 4. **President.** The President shall have been a member of The Academy for at least five years. He shall preside over all meetings of The Academy, the Executive Committee, the Budget Committee, and the Council, and shall be responsible for the administration of the business of The Academy during his term of office. He shall appoint all standing committees not otherwise provided for and such other committees as he may deem necessary. He may, with approval of the Council, call such special meetings as to him seem necessary.

Sec. 5. **President-Elect.** The President-Elect shall have been a member for at least four years. He shall have the ordinary status of vice-president. He shall familiarize himself with the duties of the presidency and shall accede to that office the following year.

Sec. 6. **Secretary.** The Secretary shall have been a member for at least three years. He shall serve as secretary of all meetings of The Academy, the Executive Committee, the Budget Committee, and the Council. He shall keep permanent records of the activities of these bodies and shall issue notices of all meetings. He shall maintain a

correct and up-to-date list of members in good standing and shall be prepared at all times to provide officers and committees with membership lists necessary to their operation.

Sec. 7. **Director of Public Relations.** The Director of Public Relations shall provide notices of meetings and any other information which will acquaint the public with the work of The Academy.

Sec. 8. **Treasurer.** The Treasurer shall have been a member for at least three years. He shall have custody of all funds of The Academy except as otherwise provided. He shall issue statements and receive payment of dues and assessments and shall pay bills chargeable to The Academy. He shall promptly submit his records for audit and shall report to the Executive Committee annually on the financial standing of The Academy. He shall be responsible for filing such financial reports as may be required by State or Federal offices.

Sec. 9. **Editor.** The Editor shall have been a member for at least three years and shall be familiar with procedures of publication. With the advice of the Publications Committee, he shall have charge of assembling, editing, and publishing the Proceedings of The Academy and shall be responsible for other duties assigned to his office by the Executive Committee.

Sec. 10. **Vacancies.** Except as otherwise provided, a vacancy occurring in any office shall be filled until the next annual meeting by appointment by the President, with approval of the Council.

Article IV. SECTIONAL ORGANIZATION

Sec. 1. The organization of Sections, defined by subject matter, may be authorized by the Executive Committee when such action is requested. A Section may be dissolved by the Executive Committee on becoming inactive or with the consent of members of the Section. Any member of The Academy may register as a member of any Section or Sections by notifying the Secretary of The Academy and meeting the requirements and obligations imposed by the Section.

Sec. 2. At the annual meeting, each Section shall elect, by vote of its members present, a chairman to preside at its meetings the following year and to serve as a member of the Executive Committee. The chairman of a Section shall appoint a proxy for any temporary emergency. Subject to approval of the Executive Committee, each Section may provide for its own organization and conduct its own meetings.

Sec. 3. Expenses incurred by a Section shall in no way become a financial obligation of The Academy except as provision has been made for them in the annual budget of The Academy.

Sec. 4. The following are hereby recognized as Sections de facto and authorized to continue operation, subject to the provisions of this Article, without further action by The Academy: Anthropology, Bacteriology, Botany, Chemistry, Entomology, Geology and Geography, History of Science, Mathematics, Physics, Psychology, Soil Science, Plant Taxonomy, and Zoology.

Article V. COMMITTEES

Sec. 1. **Standing Committees Appointed Annually.** The following named committees shall be appointed by the President, to serve for

one year except as rotation is provided, and, except as otherwise provided, shall be announced at the beginning of his term of office. He shall designate one member of each committee as chairman. All appointees to membership on committees shall be members of The Academy in good standing.

(1) **The Academy Representative on the Council of the American Association for the Advancement of Science.**

(2) **Auditing.** The Auditing Committee shall audit the books of the Treasurer and of any other officers or committee having custody of funds of The Academy. It shall report such audits at the annual meeting or at other times as required by the Executive Committee.

(3) **Youth Activities.** The Youth Activities Committee shall consist of 12 members representing diverse scientific backgrounds and about equally divided among colleges, universities, and secondary schools, and including the directors of the various youth activities related to The Academy. The duties of this Committee shall be to coordinate the Academy-sponsored programs in science for secondary schools, to formulate general policies for such activities for which The Academy has accepted some responsibility, and to advise the President on the appointment of persons to lead such activities.

(4) **Library.** The Library Committee shall have charge of all matters concerning the John Shepard Wright Memorial Library and its relation to the State Library.

(5) **Nominations.** The Committee on Nominations shall consist of at least three members selected from past presidents of The Academy. At the annual meeting, it shall submit nominations for the elective officers of The Academy. At the discretion of the President, announcement of the membership of this committee may be withheld until the time of its report.

(6) **Program.** The Program Committee shall prepare the programs and make all arrangements for regular or special meetings of The Academy and its various Sections.

(7) **Publication.** The Committee on Publication shall advise the Editor in matters pertaining to the publication of the Proceedings of The Academy and to other duties assigned to the Editor's office by the Executive Committee.

(8) **Relation of Academy to State.** The Committee on the Relation of The Academy to the State shall have charge of all relations between The Academy and the State government.

(9) **Membership.** The Membership Committee shall receive applications for membership and submit reports and recommendations on such applications at regular meetings of The Academy.

10. **Fellows.** The Committee on Fellows shall be composed of Fellows, one from each subject-matter Section. The regular term of membership shall be three years, except, that on the adoption of this constitution, the President shall appoint approximately one-third of the members for terms of three years, one-third for two years, and one-third for one year. Any interim vacancy shall be filled by appointment for the remainder of that term.

This committee shall review the membership, receive nominations, and, at least two weeks before the date of annual meeting, submit to the Secretary, for transmittal to the Executive Committee, nominations for the rank of Fellow.

(11) **Resolutions.** The Committee on Resolutions shall prepare and submit resolutions at meetings of The Academy.

(12) **Invitations:** The Committee on Invitations shall receive invitations from institutions which offer their facilities and services as hosts for meetings of The Academy and shall make recommendations to the Executive Committee as to places for future meetings.

(13) **Necrologist.** The Necrologist shall report annually on the loss of members by death and shall offer memorial resolutions.

(14) **Parliamentarian.** In addition to the performance of the regular duties of this office, the Parliamentarian shall make his services available, in an advisory capacity, for the formulation of proposed amendments to the Constitution and By-Laws and shall keep these documents up to date by incorporating in them all amendments adopted by The Academy.

Sec. 2. **Elected Committees.** The following are recognized as de factor elected standing committees, and vacancies as they occur in the rotating membership shall be filled by election by the Executive Committee. Interim vacancies shall be filled by appointment by the President for the remainder of the terms.

(1) **Academy Foundation.** The Trustees of The Academy Foundation (two members, with rotating two-year terms) shall have custody of the funds and investments of The Academy Foundation and shall report, annually or on demand, to the Executive Committee on the state of these resources.

(2) **Bonding.** The Bonding Committee (two members, elected annually) shall be responsible for the adequate bonding of all officers and committees having charge of funds or investments of The Academy.

(3) **Research Grants.** The Research Grants Committee (five members, elected for five-year rotating terms, with the President and Secretary as members ex-officio) shall receive applications and make research grants from funds designated by The Academy for that purpose. This Committee shall report annually to the Executive Committee.

Sec. 3. Special committees may be appointed by the President at his discretion or by order of the Executive Committee.

Sec. 4. Expenses incurred by committees shall in no way become a financial obligation of The Academy except as provision has been made for them in the annual budget.

Article VI. EXECUTIVE COMMITTEE, COUNCIL, AND BUDGET COMMITTEE

Sec. 1. The **Executive Committee** shall consist of the past presidents, the current officers, the chairmen of the Sections, the chairmen of all committees, the directors of the programs of the Youth Activities Committee, and representatives of affiliated organizations. (See By-

Laws, Art. VI.) This Committee shall be responsible for all matters of policy and shall supervise all activities of The Academy not expressly provided for otherwise.

Sec. 2. The Executive Committee shall hold regular meetings preceding the fall and spring meetings of The Academy. The members of the Committee present at any meeting shall constitute a quorum, provided that notice of the meeting has been given at least 15 days in advance of the meeting.

Sec. 3. The **Council** of The Academy shall consist of the current officers, with the chairman of the Committee on Relation of the Academy to the State as a member ex-officio. The Council shall transact all emergency business of The Academy that cannot be postponed until the next regular meeting of the Executive Committee. The Council may be called in session at any time by the President. He may submit specific questions to the Council by correspondence at any time. The Council may invite committee chairmen or other members to meet with it at any time.

Sec. 4. The **Budget Committee** of The Academy shall consist of the following who will hold the specified positions for the next calendar year: (1) The Council; (2) the retiring President and the retiring Secretary and Treasurer (in the year in which these officers change); (3) the Director of the Junior Academy of Science; (4) the chairman of the Program Committee; (5) the chairman of the Library Committee; and (6) the chairman of the Youth Activities Committee. Other committee chairmen and members, retiring or current, may be present by invitation. The Budget Committee shall meet in the period between November 15 and December 15 to formulate and approve the budget of The Academy for the following calendar year.

Article VII. MEETINGS

Sec. 1. The Academy shall hold two regular meetings each year, one to be known as the **annual** (or **fall**) **meeting** and one to be known as the **spring meeting.** The place of the annual meeting shall be determined by the Executive Committee on recommendation of the Committee on Invitations. The exact time of both meetings and the place of the spring meeting shall be determined by the Program Committee in consultation with the President.

Article VIII. AMENDMENT

Sec. 1. This constitution may be amended at any annual meeting of The Academy by affirmative vote of three-fourths of the members in attendance and voting, provided that the amendment has been approved by the Executive Committee and has been submitted to the membership at a previous regular meeting, or by mail, at least 30 days prior to the date on which the amendment is presented for adoption.

Article IX. ADOPTION AND CONTINUANCE OF POWERS

Sec. 1. This constitution may be adopted by affirmative vote of three-fourths of the members of The Academy present and voting at any annual meeting, provided that it has been approved by majority

vote of the Executive Committee of that body and has been presented to the membership by mail at least 60 days prior to the date on which it is presented for adoption.

Sec. 2. All actions taken by The Indiana Academy of Science previous to adoption of this constitution, and not in conflict with it, are hereby specifically confirmed until changed by formal action under the provisions of this constitution.

BY-LAWS

Article I. DUES

Sec. 1. Initiation fees and annual dues for the different classes of membership shall be determined by the Executive Committee.

Sec. 2. Annual dues are payable in advance on a calendar basis.

Sec. 3. Any members whose dues are in arrears for two years as of December 31 shall be dropped from the roll of membership. A member dropped for delinquency in payment of dues may be restored to full and continuous membership by payment of all delinquent dues.

Sec. 4. Each member is entitled to one copy of the Proceedings of The Academy for any year for which his dues have been currently paid. On payment of delinquent dues, a member may receive the Proceedings for those years if copies are available. Any member elected at either the spring meeting or fall meeting, with his membership to begin the following January, is entitled to one copy of the Proceedings for the year in which he is elected.

Article II. BONDING

Sec. 1. On recommendation of the Bonding Committee, the Executive Committee shall determine the amounts for which officers or committees having responsibility for the custody of funds or investments of The Academy shall be bonded.

Article III. EXPENDITURES

Sec. 1. The Treasurer is authorized to issue checks in payment of bills submitted by officers or committees for which provision has been made in the budget for that year, provided that any bill for fifty dollars or more shall be approved by the President.

Article IV. OPERATION OF COMMITTEES

Sec. 1. The operation of committees shall be conducted by correspondence as far as practicable, but meetings may be called by the chairmen. Except as otherwise provided, each committee shall determine its own policies and operational procedures.

Sec. 2. The President and President-Elect shall be members ex-officio of all committees.

Article V. YOUTH ACTIVITIES

Sec. 1. The Youth Activities Committee shall advise the President of The Academy on policies agreed upon by its authorized representatives concerning any program for secondary school students for which The Academy has assumed any degree of sponsorship. At present, these programs include: (1) The Indiana Science Talent Search, (2) The Indiana Science Fairs, and (3) The Indiana Junior Academy of Science.

Sec. 2. Each of these programs shall have a Director and an Advisory Committee, appointed by the President of The Academy on

advice of the Youth Activities Committee. The Director of each program shall report to the Executive Committee of The Academy and to the Youth Activities Committee at the annual meeting of The Academy.

Sec. 3. The Advisory Committee of the Junior Academy shall be called the Junior Academy Council. At least four members of this Council shall have been acting science club sponsors for at least three years. Each member of the Council shall serve for five years, and the terms shall be staggered. The Council shall include representatives from as many geographical regions of the State as possible. It shall administer the program of the Junior Academy and shall work cooperatively with the Youth Activities Committee in determining policies and in appointment of new Council members. The Council shall designate one of its members as Director of the Junior Academy of Science.

Sec. 4. The Visiting Scientists' Program, a temporary enterprise, dependent upon grants from the National Science Foundation, shall have a Director, appointed by the President to The Academy, on consultation with the Youth Activities Committee. He shall be free to select his own steering committee.

Sec. 5. The financial support and working policies of the various youth activities shall be the responsibility of their respective directors and advisory committees, with the assistance of the Youth Activities Committee. No financial obligation shall be incurred in the name of The Academy.

Article VI. AFFILIATED ORGANIZATIONS

Sec. 1. The Academy may, by act of the Executive Committee, offer its services to any other organization whose objectives are essentially the same as those of The Academy and which may petition to be affiliated with it.

Sec. 2. The Academy shall not be held responsible for any expenses incurred by any affiliated organization beyond those specifically provided for in the annual budget of The Academy.

Article VII. QUORUM

Sec. 1. Twenty-five members in good standing shall constitute a quorum for the transaction of business in any regular meeting of The Academy or in any special meeting, notice of the time, place, and purposes of which has been given to the membership by mail at least 30 days in advance.

Article VIII. RULES OF PROCEDURE

Sec. 1. The procedure of meetings of The Academy and of the Executive Committee shall be governed by Robert's Rules of Order.

Article IX. AMENDMENT

Sec. 1. These By-Laws may be amended at any annual meeting of The Academy, provided that notice of the proposed amendment has been given to the membership at a previous meeting of The Academy, or by mail, at least 30 days in advance of the meeting.

NEW MEMBERS — 1964

Adams, James Edwin, 707 Anita St., Bloomington, Ind. A

Adams, William H., 707 Anita St., Bloomington, Ind. A

Arnold, Vernon (Wilson), 7410 Delaware, Hammond, Ind. C

Bakker, Dr. Gerald R., Earlham College, Richmond, Ind. C

Barr, David J., 3303 E. Powell Ave., Evansville, Ind. G

Bascom, Miss Karleen A., Dept. of Pharmacology, Myers Hall 308, Indiana Univ., Bloomington, Ind. Z

Beers, Dr. Thomas W., Dept. of Forestry and Cons., Purdue University, Lafayette, Ind. Bo, PT

Bellis, James O., 403 Redbud Hill Apts., Bloomington, Ind. A

Bennett, Mrs. Alice, 1723 Alden Rd., Muncie, Ind. C

Bennett, Escal S. (Meteorologist), 438 S. High School Rd., Indianapolis, Ind. 46241 G

Bevington, Mr. John, 206 Lincoln St., Rensselaer, Ind. Bo

Birdwhistell, Dr. R. K., Dept. of Chem., Butler Univ., Indianapolis, Ind. C

Bram, Dr. Ralph A., Dept. of Entomology, Purdue Univ., Lafayette, Ind. E

Brigadier, Mr. Walter, c/o Westcott, 257 College Ave. Chambersburg Pa. Z, E

Britt, Miss Bonnie Jean, 615 N. Woodlawn, Bloomington, Ind. A

Burkhardt, Richard Wellington, Jr., 6 Woodridge Drive, Muncie, Ind. H

Burns, John Thomas, R. R. No. 3, Crawfordsville, Ind. Z

Burns, Dr. Maurice, Dean of College, Marion College, Marion, Ind. Ba

Buskirk, William H., 9500 E. 86th Street, Indianapolis, Ind. Z

Butcher, Dr. J. W., Dept. Ent. M. S. H., East Lansing, Mich. E

Byrnes, Dr. William R., Dept. of Forestry & Cons., Purdue Univ., Lafayette, Ind. SS

Cavender, Dr. James C., Wabash College, Crawfordsville, Ind. Bo

Cole, Dr. Thomas A., 614 E. Wabash Ave., Crawfordsville, Ind. Z

Corliss, Prof. Donald James, Box 289, Marion College, Marion, Ind. M

Craig, Michael A., R. R. 1, c/o Homer Jeffrey, Yorktown, Ind. Bo, Z

Crankshaw, Dr. William B., Dept. of Biol., Ball State College, Muncie, Ind. Bo

DeBlase, Mr. Anthony F., Box 453, Earlham College, Richmond, Ind. Z

Dellinger, Robert Donald, 4163½ Otterbein Ave., Indianapolis 27, Ind. Bo, Z

Deufel, Robert D., Indiana Central College, Indianapolis, Ind. Ba

Eddleman, Harold Lee, Dept. Biol. Science, Purdue Univ., Lafayette, Ind. Ba

Eiser, Dr. Arthur L., 921 W. Yale Ave., Muncie, Ind. PT

Evers, Philip Alden, 1500 S. 8th St., Terre Haute, Ind. Z

Gammon, Dr. James Robert, 510 S. Jackson St., Greencastle, Ind. Z

Gehring, Charles Lewis, R. R. 7, 6052 N. Fruitridge Ave., Terre Haute, Ind. Bo

Giese, Ronald L., Dept. of Entomology, Purdue Univ., West Lafayette, Ind. E

Gillooly, Charles J. Jr., 139 Hugo 8, San Francisco, Calif. E

Gruber, Cheryl Ann, 420 S. Fess, Bloomington, Ind. A

Gussin, Dr. Arnold E. S., Butler Univ., Indianapolis, Ind. Z

Harper, Miss Sue E., 213 S. W. 18th St., Richmond, Ind. Bo

Hassler, Mr. Craig, 413 E. Henna St., Greencastle, Ind. 46135 Ba, Z

Hastings, John R., 1882 Princeton Ave., St. Paul 5, Minn. C

Hatcher, Charles O., Box 415, Earlham College, Richmond, Ind. Z

Henzlik, Dr. Raymond E., 1805 Winston Dr., Muncie, Ind. Z

Hofstetter, Prof. Henry, Div. of Optometry, Indiana Univ., Bloomington, Ind. Ps

Houlihan, Mr. John Frank, 717 N. 17th St., Springfield, Ill. Ph

Howe, Mrs. Jean M., 106 Drury Lane, West Lafayette, Ind. C

Hughes, Dr. Harold K., Dept. of Physics, Indiana State College, Terre Haute, Ind. Ph

Hull, Dr. Jerome, Dept. of Hort., Purdue Univ., West Lafayette, Ind. SS

Hully, Don. 1404 E. Stop 11 Road, Indianapolis, Ind. G

Humphrey, Stephen, Box 464, Earlham College, Richmond, Ind. Z

Jacobs, Merle E., Research Prof. in Zoology, Goshen College, Goshen, Ind. Z

Koble, John R., 4256 Otterbein Ave., Indianapolis, Ind. Ba, C

Koyanagi, Mr. Elliott Y., 2630 Dekist St., Bloomington, Ind. C, Ph

Lallathin, Prof. Bernard R., 2808 W. 12th St., Anderson, Ind. Bo

Lease, William H., 104 S. 9th St., Lafayette, Ind. E

MacLean, Dr. David B., 1007 S. College, Greencastle, Ind. C

McLain, Stuart, 2323 South 9th Street, Lafayette, Indiana A

McReynolds, H. E., 5345 Mark Lane, Indianapolis, Ind. Z

Miller, Melvin (Saul), Dept. Ento. c/o J. M. Ferris, Purdue Univ., Lafayette, Ind. 47907 E

Monke, Dr. Edwin J.. Dept. of Agric. Engineering, Lafayette, Ind. SS

Montgomery, Robert H., 333 Bluebird Ave., Crown Point, Ind. SS

Morgan, William E., 918 7th St., Tell City, Ind. G

Newman, Prof. James E., Dept. of Agron., Purdue Univ., West Lafayette, Ind. SS

Parrish, Dr. Clyde F., Chem. Dept., Indiana State College, Terre Haute, Ind. C

Persell, Mrs. Joan V., 60 Venoy Dr., Indianapolis 27, Ind. Bo, PT

Pettee, Miss Ruth E., Box 512, Earlham College, Richmond, Ind. Z

Phelps, James M., Jr., 305½ National Rd. West, Richmond, Ind. Z

Poorman, Lawrence (Gene), 540 Grandview Drive, Bloomington, Ind. Ph

Randall, Rogers E., 2750 W. 12th Ave., Gary, Ind. 46404 C, Ph

Reynolds, Dr. W. Ann (King), 2214 N. Linden, Muncie, Ind. Z

Rhykerd, Dr. Charles L., 164 Blueberry Lane, West Lafayette, Ind. Bo

Salaba, David G., 649 Tyler St., Gary, Indiana Ba

Saxman, (Francis) Ray, 1316 N. Wabash Ave., Hartford City, Ind. C

Segal, Edwin S., Evermann Apts., No. 243, Bloomington, Ind. A

Sherfey, Miss Geraldine Richards, 7023 Wicker Ave., Hammond, Ind. Ps, Z

Smail, J. Kenneth, 615 East 11th St., Bloomington, Ind. A

Smith, James Mitchell, P. O. Box 478, Anderson College, Anderson, Ind. G, SS

Smith, Paul L., Jr., 425 S. River Road, West Lafayette, Ind. Ba, Bo

Steele, A. Logan, 9111 Kerwood Drive, Indianapolis, Ind. 46240 Ps

Steele, Mrs. Joan P., 9111 Kerwood Drive, Indianapolis, Indiana 46240 A

Swartz, Dr. B. K., Jr., Ball State Teachers College, Muncie, Ind. A

Tomak, Curtis H., 210 N. E. 9th St., Linton, Ind. A

Tukey, Dr. Ronald B., Dept. of Hort., Purdue Univ., West Lafayette, Ind. C, SS

Uhlhorn, Dr. Kenneth W., 1812 South 25th St., Terre Haute, Ind. Z

Urbont, Allan L., 515 East 10th St., Bloomington, Ind. A

Wade, Miss Susan E., Box 796, Earlham College, Richmond, Ind. Z

Waltman, William B., 2216 Riveria Dr., Indianapolis Ind. A

Wenner, Kenneth A., 858 Carol Drive, Crown Point, Ind. SS

West, Terry R., School of Engineering, Purdue Univ., Lafayette, Ind. G

Wilhelm, Prof. H. G., Jr., Franklin College, Franklin, Ind. Ba

Yablonsky, Charles, 926 Sheridan Street, Union, N. J. Z

Ziemer, Dr. Paul L., Bionucleonics Dept., Purdue Univ., Lafayette, Ind. Ph

Zimmack, Dr. Harold L., 2517 Lancaster Drive, Muncie, Ind. E

Zimmerman, Earl G., 1100 Buckeye, Terre Haute, Ind. Z

Zimmerman, Dr. John F., Wabash College, Crawfordsville, Ind. C

Northwest High School Science Club, 34th & Moeller Sts., Indianapolis, Ind.

Science Club, Hartford City High School, Hartford City, Ind.

INDIANA JUNIOR ACADEMY OF SCIENCE

OFFICERS 1964-65

President: Gary Gunther, Washington High School, Indianapolis.

Vice-President: Bob Stallman, John Adams High School, South Bend.

Secretary: Susan Mann, University High School, Bloomington.

Junior Academy Council: Dr. Howard Michaud, Purdue University, Lafayette (chairman); Miss Helen Reed, Manual High School, Indianapolis (1962-1966); Mr. Erwin Steinkamp, New Albany High School, New Albany (1963-1967); Sister Marian Francis, Reitz Memorial High School, Evansville (1964-1968); Mr. Keith Hunnings, New Haven Senior High School, New Haven (1965-1969).

Director: Professor Donald Winslow, University High School, Bloomington.

PROGRAM OF THE THIRTY-SECOND ANNUAL MEETING

October 31, 1964

8:30-10:00 a.m. Registration of all members, sponsors, and guests, lobby of Ransbury Auditorium, Academic Hall.

9:00-10:15 a.m. Interviews of the Junior Academy Council, Room 18, Lilly Science Hall.

9:30-10:00 a.m. Election of new officers, lobby of Ransbury Auditorium.

10:00-12:00 noon Presentation of papers in science and mathematics by Junior Academy members, Ransbury Auditorium.

12:00-1:00 p.m. Luncheon, College Cafeteria, Academic Hall.

1:15-3:00 p.m. Annual business meeting, Ransbury Auditorium. Greetings by Mr. Wayne Dunbar, Emmerich Manual Training High School, Indianapolis; Address: "Discovery," by Dr. Howard T. Black, Associate Professor of Physics, Indiana State College, Terre Haute; presentation of new officers, Junior Academy Council, special guests and awards. President Gary Gunther, presiding.

The following papers were read by members of the Junior Academy during the morning session:

1. A Study of Common Metals and Metallic Oxides Used as Catalysts in Oxygen Liberation. Jack Dahl, Sigma Mu Club, Franklin Central High School, Acton.
2. Can Turtles Learn? Dennis Waltke, MSE Academy, University Junior High School, Bloomington.
3. Rocketry. William Reisz, Reitz Memorial Chapter of FSA, Reitz Memorial High School, Evansville.

4. The Spark Chamber, Bill Inwood, Junior Engineering Technical Society, Central High School, South Bend.
5. Lasers. Paul Froehle, Reitz Memorial Chapter of FSA, Reitz Memorial High School, Evansville.
6. Effect of Certain Spices on Food Decay. Malinda Finch, Portland Science Club, Portland High School, Portland.
7. Analysis of the Color-Magnitude Diagram of the Globular Cluster M53. Phil Bowers, Science Club, Huntington High School, Huntington.
8. The Electroencephalograph: Detector and Recorder of Brain Wave Patterns in Normal and Abnormal Brain Functions Patricia Bredhold, Reitz Memorial Chapter of FSA, Reitz Memorial High School, Evansville.
9. Basic Structure and Constituents of Nictonic Vitamins. Gordon B. Linn, Sigma Mu Club, Franklin Central High School, Acton.
10. An Antibiotic from the Soil. Nerrida King, MSE Academy, University Junior High School, Bloomington.
11. Condensing of Natural Gas into "Drip Gasoline." Steve Kincaid, Reitz Memorial Chapter of FSA, Reitz Memorial High School, Evansville.
12. Polyanions as Inhibitors of Ribonuclease. David Jones, Sigma Nu Club, Franklin Central High School, Acton.
13. Groups and Subgroups of Projective Transformations on a Line and About a Point. Cynthia Hedstrom, Hartford City Science Club, Hartford City High School, Hartford City.
14. The Chemotherapy of Plant Callus Growth. Mickey O'Leary, Reitz Memorial Chapter of FSA, Reitz Memorial High School, Evansville.
15. Theory of Semiconduction. Michael Humnicky, Junior Engineering Technical Society, Central High School, South Bend.
16. The Influence of Age on Stereopsis. Susan Hofstetter, E. Wayne Gross Academy of Science, University High School, Bloomington.
17. Absorption of Gamma Radiation from RA^{226}, Mary Ellen Lancaster, Sigma Mu Club, Franklin Central High School, Acton.
18. Determination of Artificial Coloring in Oranges by Paper Chromatography. Marsha Russell, George Washington High School, Indianapolis.
19. Hydrolysis of Adenosine Triphosphate by Myosia ATP-ase Within the Actomysin Complex. Gary Gunther, George Washington High School, Indianapolis.
20. Immunization Against Streptococcal Infections in Mice. John Darsee, John Adams High School, South Bend.

MINUTES

The thirty-second annual meeting of the Indiana Junior Academy of Science was held Saturday, October 31, 1964, on the campus of Indiana Central College in Indianapolis. The host for the meeting was the Saturday Morning Science Club of Emmerich Manual High School, Indianapolis. Mr. Wayne Dunbar and Mr. Dave Otto are the faculty sponsors of this host club.

Members, sponsors, and guests attending the annual meeting registered from 8:30 to 10:00 a.m. in the lobby of the Ransbury Auditorium of Academic Hall. Authorized members from attending science clubs were given ballots with a list of nominees which were submitted by the Junior Academy Council from names received from club sponsors. A brief statement describing each candidate's achievements in science was included in the listing. Voting for the 1965-66 officers took place at this time.

Mr. Erwin Steinkamp, member of the Council of the Junior Academy, opened the general session of the program at 9:45 a.m. in the Ransbury Auditorium. Mr. Steinkamp briefly welcomed all students and sponsors to the meeting and then introduced Bob Stallman, vice-president of the Junior Academy. Bob presided over the presentation of papers in the fields of science and mathematics by Junior Academy members. A total of twenty papers, as listed in the program, covering varied student projects were heard during the morning meeting.

During the presentation of papers in the Ransbury Auditorium, the Junior Academy Council conducted interviews for the award of "Best Boy" and "Best Girl" in science. Vice-President Bob Stallman excused himself briefly from the program for one such interview. In his absence, Susan Mann, secretary of the Junior Academy, presided during the presentation of papers.

Following the completion of all twenty papers, Bob introduced Mr. Wayne Dunbar, sponsor of the host club, the Saturday Morning Science Club. Mr. Dunbar directed those in attendance to the College Cafeteria in Academic Hall where luncheon was served.

Gary Gunther, president of the Junior Academy of Science, called the annual business meeting to order at 1:25 p.m. in the Ransbury Auditorium. Mr. Wayne Dunbar opened the meeting by officially greeting all students and teachers. He pointed out that the caliber of the papers presented earlier predicts that science teachers of the future will have to "run hard to keep up" with their students. Mr. Dunbar encouraged the students when he remarked that although the Junior Academy may be small in number, it is always the greatness of the minds in a group that counts—not the size of the group.

Gary introduced Susan Mann who read the minutes of the thirty-first annual meeting to the Junior Academy. No additions or corrections were offered; thus, the minutes were approved.

Gary then introduced Dr. Howard T. Black, Associate Professor of Physics at Indiana State College in Terre Haute, who addressed the group. Dr. Black admitted that the title of his talk—"Discovery"—was chosen before he had planned exactly what the lecture would entail. He reviewed many historic discoveries and from these drew an interesting generalization concerning the process of human exploration in science. Dr. Black began by describing Sir Isaac Newton's discovery of the spectrum of the sun which appeared as a fascinating rainbow. Fraunhofer, a German scientist, later improved upon Newton's findings when he discovered a discontinuous or line emission spectrum. This is an example, Dr. Black pointed out, of how additional information is gained in science by "taking a closer look" at a subject matter with improved equipment and technology.

Continuing along the same line of inquiry, Dr. Black described how Kirchhoff and Bunsen devised laws for spectral analysis through extensive study of light given off by different gases. To illustrate this achievement, Dr. Black distributed small diffraction gratings to the audience and illuminated three different gases—helium, mercury, and neon. Thus, the Academy members "made discoveries" of their own of the difference of spectral lines produced by different types of light.

Dr. Black explained how, because of his curiosity, man has continued to take a closer and closer look at the beautiful rainbow seen by Newton. This process of investigation has included many separate experiments by several different scientists. Dr. Black acknowledged that what he had presented was mainly a survey of information. It was presented, however, as a lesson revealing the requirements of a discovery. Discovery is a "slowly evolving process of events" brought about by "many careful observers over a long period of time." The process is one of observation, then analysis, then development of a theory, then application of theory, and finally the evolution of new theories. This, Dr. Black concluded, is discovery.

Gary expressed the appreciation of the group to Dr. Black for having spent his time to prepare his informative address. Gary then recognized Professor Don Winslow, the Director of the Junior Academy, and thanked him on behalf of the other officers for his assistance with their work. The members of the Junior Academy Council were introduced at this time. The Council includes Dr. Howard Michaud, chairman, Purdue University; Miss Helen Reed, Manual High School, Indianapolis; Mr. Erwin Steinkamp, New Albany High School, New Albany; Sister Marian Francis, Reitz Memorial High School, Evansville; and Mr. Keith Hunnings, New Haven Senior High School, New Haven.

Mr. Erwin Steinkamp, Junior Academy Council member, was recognized to announce the results of the officer elections conducted during the morning. The officers for the 1965-66 school year will be John Darsee, president, John Adams High School, South Bend; Ed Emery, vice-president, New Albany High School, New Albany; and Mickey O'Leary, Reitz Memorial High School, Evansville.

Dr. R. M. Kline, Eli Lilly and Company, presented an award to Malinda Finch, Portland High School, Portland, on behalf of the

Indiana Branch of the American Society for Microbiology. Dr. H. J. Florestana, Pittman Moore and Company, Research Division; and Dr. D. J. Niederpruem, Department of Microbiology, Indiana University Medical Center; helped in the selection of the best paper in the areas of microbiology and bacteriology. For her paper entitled "The Effect of Certain Spices on Food Decay," Malinda received a check for $25.

Miss Helen Reed, Junior Academy Council member from Manual High School, announced the winners of the awards for "Best Boy" and "Best Girl" in science for 1964. Cynthia Hedstrom, Hartford City High School, Hartford City, received the "Best Girl" in science award; and Gary Gunther, George Washington High School, Indianapolis, was named the "Best Boy" in science. The recipients of these honors will receive an honorary membership in the American Association for the Advancement of Science and a year's subscription to **Science**, a publication of the AAAS.

Before turning the meeting over to Professor Winslow, Gary thanked the faculty of Indiana Central College for the generous use of their facilities and wished all the students luck in all of these endeavors in the coming year.

Mr. Winslow, opened his remarks by congratulating the three officers—Gary Gunther, Bob Stallman, and Susan Mann—for their fine work before and during the thirty-second annual program. He felt that they had set a example which would be difficult for others to follow. Mr. Winslow then congratulated all the students who presented papers pointing out that the quality of the papers improves greatly each year. Mr. Winslow thanked particularly Mr. Dunbar, Emmerich Manual High School, Indianapolis, and Dr. Robert Brooker, Program Chairman of the Indiana Academy of Science, who gave their time and energies to make the Junior Academy meeting possible.

Mr. Winslow appealed to all students, sponsors and guests present to bring to him any suggestions for the improvement of the program for next year's meeting. One possibility suggested has been to limit the number of papers presented to provide time for other activities. If the number of papers were cut down, abstracts of each paper submitted would be required in advance. From these abstracts a certain number of papers would be selected for the privilege of presenting a paper before this group. Another suggestion has been to divide the state into two portions and to have regional meetings rather than statewide meetings. Mr. Winslow pointed out that approximately one-half of the thirty-four member clubs were situated in the northern portion of Indiana and one-half are located in southern Indiana. This division of the Junior Academy into two branches—one to accommodate the northern half of Indiana and the other the southern half—may be made necessary by the growing number attending meetings. Two hundred and twenty-eight students, thirty-five sponsors and eighty-nine guests had registered for the thirty-second annual meeting. This total of three hundred and fifty-two people attending is an increase of one hundred and eighty-eight from last year's total figure. A division of the Junior Academy would mean two separate meetings in the ex-

tremities of the state. Mr. Winslow requested comments concerning these suggestions from all Junior Academy members and sponsors.

Mr. Winslow announced that next year's meeting will be held in South Bend on the campus of Notre Dame University. The following year the meetings will be at Ball State Teacher's College in Muncie.

Mr. Winslow thanked all students, sponsors and guests in attendance expressing gratitude for their time and interest. President Gary Gunther adjourned the meeting at 2:15 p.m.

Respectfully submitted,
SUSAN MANN, Secretary

INDIANA JUNIOR ACADEMY OF SCIENCE CLUBS

JANUARY 1, 1965

Town	*School and Club*	*Sponsor*
Acton	Sigma Mu Chapter of FSA Franklin Central High School	Jerry Colglazier
Bloomington	National Scientific Honor Society Bloomington High School	Merril L. Crisler
Bloomington	E. Wayne Gross Academy University High School	Lew Wise
Bloomington	Freshman Academy of Science University Junior High School	Eugene Schlebecker
Bloomington	MSE Academy of Science University Junior High School	Charles Souers
Columbus	Science Club Columbus Senior High School	L. N. Carmichael
Crawfordsville	Up-N-Atom Crawfordsville High School	David Wells
Evansville	Reitz Memorial Chapter of FSA Reitz Memorial High School	Sister Marian Francis
Fort Wayne	Albertus Magnus Science Club Central Catholic High School	Sister Winifred
Fort Wayne	Phy-Chem Club Elmhurst High School	Ruth Wimmer
French Lick	Springs Valley Science Club Springs Valley High School	D. L. Clark
Gary	Biology Club Lew Wallace High School	Lola Lemon
Hartford City	Hartford City H. S. Science Club Hartford City High School	F. Ray Saxman
Highland	Science Club Highland High School	Jon Hendrix
Huntington	Science Club Huntington High School	Robert Diffenbaugh
Indianapolis	Brebeuf Science Club Brebeuf Preparatory School	Rev. Richard J. Middendorf, S.J.
Indianapolis	Science Club Howe High School	Jerry A. Motley
Indianapolis	Manual High School Science Club Manual High School	Wayne E. Dunbar Dave Otto
Indianapolis	Nature Club Arsenal Technical High School	Charles E. Russell
Indianapolis	Science Club George Washington High School	Elizabeth Crider
Indianapolis	Science Club of Westlane Westlane Junior High School	John Van Sickle
La Porte	Bi-Phi-Chem Club La Porte High School	Frances Gourley Byron Bernard

Town	School and Club	Sponsor
Lebanon	Junior Explorers of Science Lebanon Junior High School	Tom Ewing
New Albany	Science Club New Albany Senior High School	Erwin Steinkamp
New Haven	New Haven Science Club New Haven High School	Keith Hunnings
Portland	Science Club Portland Junior High School	Bill Norris
Portland	Portland Senior High School Science and Mathematics Club Portland Senior High School	Ralph Settle Robert Freemyer
South Bend	Junior Izaak Walton League John Adams High School	Ernest Litweiler
South Bend	JETS Junior Engineering Technical Society Central High School	Lawrence K. Cox
South Bend	IONS J. W. Riley High School	Robert C. Smith
Terre Haute	Pius X Science Teens Schulte High School	Sister Thomas Mary
Vincennes	Sigma Tau Science Club St. Rose Academy	Sister Suzanne

NECROLOGY

Will E. Edington, DePauw University

Alva Braden Beecher

Crawfordsville, Indiana
November 30, 1890

Bradenton, Florida
February 1, 1964

Long before Crawfordsville, Indiana, became noted for its literary men, it was famous in scientific circles at least for its crinoid beds located a mile north of the city on Corey's Bluff along the north bank of Sugar Creek. The Crawfordsville crinoid area is second in North America only to the beds located near Burlington, Iowa, and was well known a century ago. By the end of the nineteenth century most of the stone lily beds on Corey's Bluff had been quarried on a commercial basis, but there are still occasional fine fossil specimens to be found and the area still has considerable geological interest. It always gave Alva Braden Beecher, a most personable and accommodating man, great pleasure to conduct small groups and an occasional visiting geologist on tours over the area with which he was well acquainted. He also had considerable interest in all the life sciences and was an active member of the DePauw-Wabash Sigma Xi Club and regularly attended its dinner meetings. He was interested in science as an avocation for professionally he had spent most of his life in newspaper work.

Alva Braden Beecher was born in Crawfordsville, Indiana, on November 30, 1890, and graduated from its High School in 1911. Most of his life was spent in Crawfordsville, but during the World War I period he was employed by the street railways in Indianapolis and the death of his wife occurred during this period. He graduated from Wabash College in 1924 but he had previously attended Butler University and later the Indiana University Medical School where he remarried in 1921. While attending Wabash College he accepted employment in 1923 with the old Crawfordsville Journal, which later became the Journal-Review, where he became manager of the advertising department from which he retired on January 1, 1957. Following his retirement he and Mrs. Beecher spent most of each year in Florida, but he returned to Crawfordsville each summer and substituted for members of the advertising department during their vacations. He died suddenly of a heart attack on February 1, 1964, in Bradenton, Florida.

Mr. Beecher was a very civic minded business man, being an active member of the Montgomery County Chamber of Commerce for over twenty-five years. He served as a precinct committeeman for over forty years and represented the Crawfordsville Second Ward in the City Council from 1948 to 1958. Early in life he became a member of the Lions Club and later an active member of the Kiwanis Club

until his retirement. He possessed a pleasing personality and was always delighted to meet and work with others.

Long an active Mason, he was deeply interested in DeMolay and participated in the work of the Eastern Star of which Mrs. Beecher had served as Worthy Matron. Masonic graveside services were conducted for him in the Crawfordsville Oak Hill Cemetery. He was also a member and deacon of the Crawfordsville Wabash Avenue Presbyterian Church.

Over the years Mr. Beecher was interested in biology as well as geology. He joined the Indiana Academy of Science in 1949 and was well known to Wabash College and DePauw University Sigma Xi members. In his retirement he spent much of his time with his boat and camera studying water and shore birds. Alva Braden Beecher possessed the spirit and enthusiasm of a naturalist.

GLENN ALBERT BLACK

Indianapolis, Indiana — Evansville, Indiana
August 18, 1900 — September 2, 1964

"Books have been written to propound, in terms of the philosophy of history, the aims and objects of archaeological research. But every archaeologist knows in his heart why he digs. He digs in pity and humility that the dead may live again, that something may be salvaged from the wreck of the ages, that the past may color the present and give heart to the future. His excavations are the only payment that we can make against the debt we owe to those who, through the millenia, fashioned the world in which we live."

Glenn Albert Black used this quotation from Geoffrey Bibby's volume, "The Testimony of the Spade," in his comprehensive review of archaeological work in Indiana which appeared in the April, 1961, number of the Indiana History Bulletin. No one could have written on Indiana archaeology with greater authority than Glenn Black, for he had spent over thirty years as archaeologist for the Indiana Historical Society. His scholarly article traces archaeological work done in Indiana beginning with Charles Alexander Leseuer, one of the scientists at New Harmony, down through the State Geologists, Cox, Collett, Gorby, and such naturarists as Moses N. Elrod, Rufus Haymond and Gerard Fowke, to the present. Glenn Black knew more about the prehistory of Indiana than any other living man.

Glenn Black was born in Indianapolis on August 18, 1900. Following his graduation from Indianapolis Technical High School it took some time for him to find his life's work. He served as an estimating engineer for the Fairbanks-Morse Company in Indianapolis several years before taking up archaeology as a profession. He had attended Ohio State University and had studied under Henry C. Shetrone, Archaeologist for the State Museum of Ohio, in Columbus, who lectured at Ohio State University in 1928-1929, and who influenced Black to dig for the secrets of the past.

In 1928 the Indiana Historical Society began a systematic archaeological survey of the 92 counties of the State. Black was appointed

the Historical Society Archaeologist in 1931 and made his first report of a visit in April, 1931, to the site of the so-called Fort Azatlan on the Wabash near Merom, in Sullivan County, and of visits to several other sites along the Ohio River in Eastern Indiana. In May, 1931, a visit to the Angel Mounds Site was made by Warren King Moorehead, nationally known Ohio archaeologist, Eli Lilly, E. Y. Guernsey and Glenn Black, but it was not until 1938 that the Indiana Historical Society, through private subscription, purchased the Angel Mounds Site of 450 acres. In the meantime Black worked in Greene County in the summer of 1931, Dearborn, Ohio and Owen Counties in 1932 and 1933, Blackford County in 1934, and excavated the Nowlin Mound in Dearborn County in 1935. He described his work in Greene County in a 163-page report, "The Archaeology of Greene County," in Vol. 10, 1933, of the Indiana History Bulletin, and the "Excavation of Nowlin Mound" findings, a 132-page article in Vol. 13, 1936. Briefer reports on other investigations appeared regularly in the Indiana History Bulletin. When not in the field he gave numerous talks over the State before county historical societies, service clubs, research clubs, schools and school organizations, and over the radio. For example, during the year 1933-1934 he gave 26 talks not including two radio broadcasts over Station WLW. Lecturing became a definite part of his work through the rest of his career. By 1942 he was illustrating his lectures with lantern slides in color before audiences of 150 to 600.

Following the purchase in 1938 of the Angel Mounds Site by the Indiana Historical Society Black took charge of the archaeological work. In August, 1938, the Works Progress Administration considered a project sponsored by the Historical Society which was approved that fall and which permitted the "employment of needy persons on archaeological research in Indiana," the WPA to provide 88.69% of the required monetary allotment. Work was begun on clearing the site in April, 1939. The excavation of the mound began in June, 1940, with over 200 WPA laborers at work during the Spring of 1940. However, the WPA stopped the work in the Spring of 1942, owing to improved labor employment conditions in Evansville, although the mound excavation was not completed, and for a time no work was done on the site.

In 1944 Indiana University added Archaeology to its campus curriculum with Glenn Black employed in the Department of Zoology as a Lecturer in Archaeology. In 1945 the University and the Historical Society cooperated in establishing a Field School at Angel Site with Black in charge. By 1948 a kitchen and mess hall and two dormitories had been provided at the Site and eleven students spent the Summer in field work. Black was Director of the Field School until the time of his death. For the Summer of 1963 he was Lecturer in Anthropology for Indiana University and gave a course, "Field Work in Archaeology and Physical Anthropology," and directed the work at Angel Mounds. In order to be near his work he made his home for a number of years at Newburgh, Indiana, a few miles east of Evansville.

The Historical Society gave the Angel Site to the State in 1947, under the general supervision of the Department of Conservation,

cooperating with Indiana University. Also the Department of Anthropology was formed in 1947 by the University with Dr. Charles F. Voegelin as Chairman and Black became and remained a Lecturer in the new Department until 1960.

Through the interest and efforts of Eli Lilly the Archaeological Division, later the Anthropology Division, of the Indiana Academy of Science was organized in 1935 with Mr. Lilly as Chairman. Mr. Black, who had joined the Academy in 1933 and became a Fellow in 1937, succeeded Mr. Lilly as Chairman of the Division for the next three years. He presented 18 papers before the Academy, one a joint paper with Paul Weer, a number of which were published in the Proceedings. He served the Academy on several committees such as the Library, Program, and Archaeological Survey Committees, and in 1936 on the committee to assist Dr. Henry B. Ward, Permanent Secretary of the American Association for the Advancement of Science, in making arrangements for the meeting of the A.A.A.S. in Indianapolis in 1937. At the General Meeting of the Academy in 1962, in Evansville, following the completion of the Divisional Programs he held Open House at Angel Mounds and conducted a tour of the Site.

Dr. Black was a Fellow of the American Anthropology Association and served the Society of Archaeologists as Vice President in 1938, President in 1941 and Treasurer from 1947 to 1951. He was also a member of the National Research Council from 1958 to 1960. A co-founder and active member of the Lapidary Society of Evansville, he was a skilled gem cutter which he enjoyed as a hobby. He was an elder in the First Christian Church of Evansville, and held the following Masonic orders: Blue Lodge, Scottish Rite, York Rite, Lavalette Commandery, and Eastern Star.

In 1954 he was joint author with Eli Lilly, George K. Neumann, Joe E. Pierce, C. F. Voegelin, Erminie W. Voegelin and Paul Weer in the book "Walam Olum or Red Score: The Migration Legend of the Lenni Lenape or Delaware Indians." He also wrote in 1958 an illustrated 14-page booklet " "A" is for Axe—A First Reader" about some Indiana Artifacts, that was published by the Indiana Historical Society and offered free to teachers and students interested in Indian History.

All of Glenn Black's scientific work was done in Indiana but he had a national reputation as an archaeologist. His career was interesting for he was largely a self-trained archaeologist who had never completed a college course to receive a Bachelor's degree. However, his standing as a scientist was recognized by Wabash College which conferred on him in 1951 the Sc.D. degree with the following citation: "Glenn Albert Black, you have won the admiration and confidence of our historically minded citizens by your devotion to and attainment in American archaeology. Through ability in leadership, masterly technique and conscientious hard work in conducting excavations and summer training camps and by public lecturing you have won high recognition among American archaeologists and made vital contribution to the knowledge of the prehistory of Indiana."

Dr. Glenn Black died in the Deaconess Hospital in Evansville, Indiana, on September 2, 1964. Following services in Evansville, final services were held in Crown Hill Cemetery in Indianapolis.

JAMES EPHRAIM BROCK

Marion, Indiana — Lafayette, Indiana
November 22, 1891 — October 1, 1964

On December 7, 1928, the Indiana Academy of Science held its General Meeting at Indiana University. James Ephraim Brock, then an Assistant Professor of Physics at Purdue, drove his car to attend the Meeting and I accompanied him, for both of us were presenting papers before the Division of Mathematics and Physics. It was an interesting meeting for Professor Brock because six months previously he had received his Ph.D. in Physics at Indiana University and he would be able to meet Professors Foley, Ramsey, Dutcher and Hufford, all of whom like Brock had received their A.B. and A.M. degrees, and the latter two also their Ph.D. degrees, at Indiana University. Dr. Brock had received the A.B. in mathematics in 1919 and the A.M. in physics in 1923 at Indiana University. He had previously received the B.S. degree in 1913 from the Marion, Indiana, Normal College.

James E. Brock was born near Marion, Indiana, on November 22, 1891. He met the teacher requirements imposed by the State in the first decade of this century and began his teaching career in 1910 in the public schools. He continued public school teaching until 1923, taking some time out to attend Marion Normal College and Indiana University. He began his college teaching as an instructor in physics at Indiana University in 1923-1924. In 1925 he accepted an assistant professorship in physics in the Texas Agriculture and Mechanics College. In the following year he became Assistant Professor of Physics at Purdue. He left Purdue in 1930 to become an engineer with the Hazeltine Corporation in New York. He returned to teaching in 1932 as Professor of Physics and Mathematics in Brenau College in Gainesville, Georgia. Two years later he accepted the chairmanship of the Department of Physical Sciences in Nebraska State College, Wayne, Nebraska. In 1941 he became Professor and Head of the Department of Physics in Arkansas State College, located in Jonesboro and Beebe, Arkansas. He entered war work in 1942, serving a year as a Radio Engineer in the U.S. Army Signal Corps. In 1943 he returned to Purdue as an Associate Engineer working with the Small Arms Research Program under the U.S. auspices, serving as an electronics consultant. After the termination of the Program he remained at Purdue as an Associate in the Engineering Experiment Station and electronics consultant until 1948 when he was made an Associate Professor of Mechanical Engineering. He retired in 1962 as Emeritus Professor of Mechanical Engineering but continued active as a consultant to the Inland Container Corporation in McClure Park until his death in the Lafayette Home Hospital on October 1, 1964. During his life he had served for short periods as engineer for the Firestone Tire

and Rubber Company in 1920 in Akron, Ohio, and with the General Household Utilities Company in 1934 in Marion, Indiana.

Dr. Brock became both a member and a Fellow of the American Association for the Advancement of Science in 1934. He also was a member of the American Physical Society, the American Chemical Society, the Institute of Radio Engineers, Sigma Xi and Pi Tau Sigma. He was listed in American Men of Science and Who's Who in Indiana.

While he was teaching in Nebraska State he was a member of the Wayne, Nebraska, Kiwanis Club. After returning to Purdue he became a member and a past vice president of the Lafayette Lions Club. An Elder and past chairman of the Official Board of the First Christian Church in Lafayette, he had also served his church as a Sunday School teacher.

He joined the Indiana Academy of Science in 1922 and presented papers before the Division of Physics before he left Indiana and after he returned to the State. Most of his papers in recent years were presented as joint papers with graduate students, for he was in general charge of all graduate students in the School of Mechanical Engineering. He also offered a course in the development of instrumentation and he established an electronics and measurement group within the School of Mechanical Engineering.

A Committee representing the School of Mechanical Engineering stated the following about Dr. Brock after his death: "His major contributions were as a teacher, adviser and consultant to graduate students in this school. Professor Brock was always noted by his students for his kindness, patience, and thoroughness in answering their questions and to several generations of graduate students he was their confidant and friend." Dr. Brock lived a life of effective service.

GEORGE NISSLEY HOFFER

Hummelstown, Pennsylvania — Lafayette, Indiana
November 20, 1887 — December 23, 1963

The August, 1964, Indianapolis newspapers contained articles stating that a mysterious virus was attacking corn in southern Ohio and Indiana and was seriously endangering the corn yield, and the virus appeared to be spreading. A similar condition prevailed in the corn growing states east of the Mississippi River fifty years ago. Relatively very little was then known about corn diseases, soil depletion, soil aeration, fertilizers and crop rotation. However, the Indiana Legislature in 1913 had passed the Vocational Education Law which, among other things, required the teaching of agriculture in the public schools and provided for the appointment by Purdue University of County Agriculture Agents at the request of counties. The first Agents, eight in number, were appointed on July 1, 1913. The County Agents were to work directly with the farmers, live stock raisers, orchardists, and the public schools. These Agents gave little attention at first to corn except to discuss the selection, testing and storing of seed corn.

Hybrid seed corn was then almost unknown. Through farmer contacts the Agents soon discovered the seriousness of the corn problem and the Purdue Agricultural Experiment Station went to work. Before the end of the decade a young biologist, George Nissley Hoffer, was to point the way to find the true nature of corn, solve some of the problems, and ultimately receive international recognition as a plant pathologist and agronomist.

George Nissley Hoffer was born on November 20, 1887, in Hummelstown, Pennsylvania, about ten miles east of Harrisburg, in a well to do family of Dutch ancestry, going back to the famous Swiss innkeeper, Andreas Hofer. Following the completion of his public school education, he entered Lebanon Valley College, at Annville, a few miles from his home, and graduated in 1909 with a major in biology. During this time he spent one summer as a member of an expedition dredging up fish off the Bermudas, and another summer hunting fossils around Chesapeake Bay. In the Fall of 1909 he went to Purdue University as an assistant in general biology and received the M.S. degree two years later. The next three years he served as an instructor in botany, was promoted to Assistant Professor in 1914 and to Associate Professor two years later. In 1917 he became an Associate Botanist in the Agriculture Experiment Station and also an agent and pathologist for two years in charge of corn disease investigations for the Bureau of Plant Industry, U.S. Department of Agriculture. In 1929 he resigned his position at Purdue to become manager of the midwest branch of the agriculture and science bureau of the Dutch N.V. Potash Export My., Inc. Six years later he became Midwest Manager of the American Potash Institute, with offices in West Lafayette, Indiana, which position he held until his retirement in 1954. However, in 1955 he became a Consulting Agronomist for the Olin Mathieson Chemical Corporation and he continued this work until his sudden death from a heart attack on December 23, 1963, in Lafayette, Indiana.

When George Hoffer came to Purdue he was deeply interested in research. He immediately joined the Indiana Academy of Science and presented a paper at its Fall Meeting in 1909. He knew very little about corn but was interested in fungi which attack wheat, forest trees, shrubs and clover, and by 1916 he had presented seven papers before the Academy, four of which were published in the Proceedings of the Academy. However, about this time a 1915 graduate in agriculture at Purdue, James Ransom Holbert, an employee of the Funk Seed Corn Co., of Bloomington, Illinois, began working on the diseases of corn with Professor Hoffer and the two of them carried out a three-year survey in Indiana and Illinois which culminated in the publication of a joint one-page article in Science, March 8, 1918, "Results of Corn Investigations," that drew the attention of the U.S. Department of Agriculture, since their work pioneered in making biochemical studies of the corn plant itself and the chemistry of the soil.

Professor Hoffer presented a paper before the Academy in 1920 on "Corn Diseases in Indiana," which, however, was not published in the Proceedings. However, from 1919 on for a number of years, Dr. Max Gardner, a colleague of Professor Hoffer, made annual reports

in the Proceedings on "Indiana Plant Diseases," in which brief statements were given of Hoffer's estimates of corn losses in Indiana for the given year due to the fungi Diplodia, Fusarium, Gibberella and Rhizopus causing dry rot, ear rot, seedling blight, etc. Hoffer also published papers in the Journal of Agricultural Research, Journal of Agronomy, Phytopathology, and other journals besides contributing material to the Agricultural Experiment Station Bulletins. His last Bulletin, "Testing Corn Stalks Chemically to Aid in Determining their Plant Food Needs," appeared in 1930 as Purdue Bulletin 298. Before he left Purdue he and a colleague, Samuel F. Thornton, developed the Purdue Soil and Plant Tissue Test Kit, a diagnostic tool for determining chemically whether nitrogen, phosphorus or potassium was lacking in the nutrition of corn, small grains, hay and pasture. This Kit is still used by County Agents and farmers.

Following his resignation at Purdue in 1929 he made a trip to the Netherlands to meet the people directing the N.V. Potash Export My. and learn their procedures. His main work was to promote the use of potash as a fertilizer and to show the kind of fertilizer needed by making field and laboratory tests of the soil and plant tissue before County Agents, farmer groups and in some cases the individual farmer. After becoming affiliated in 1935 with the American Potash Institute in this same work he wrote a number of articles on the need and use of fertilizers which appeared in the Institute publication, "Better Corps with Plant Food." In the 1940's he invented the Hoffer Soil Sampler, a device for getting cores of soil to a depth of 16 inches without disturbing the soil profile. H. L. Garrard, a Purdue graduate and agronomist employed by the Institute, helped to develop this Sampler.

Since Hoffer's office was in West Lafayette he maintained close relations with the Purdue Agricultural Experiment Station. Previous to 1939 the belief prevailed that the dry-weather firing of corn was due to the lack of moisture in the soil. However, Hoffer cooperating with Professor George D. Scarseth and others at Purdue showed that the dry-weather firing was really due to nitrogen starvation. He also pointed out in 1955 that much of the failure generally charged to drouth could be eliminated by improved methods of cultivation and providing the soil with a higher organic matter content.

In 1949 he contributed a chapter. "Hunger Signs in Corn," to a book, "Hunger Signs in Crops," published by the American Society of Agronomy. He also wrote a chapter in a book, "Potash Deficiency Symptoms," that was published in Germany. As a consulting agronomist with the Olin Mathieson Chemical Corporation he wrote a number of bulletins on fertilizers. One of his last articles was on "Old Manure Gas and Anhydrous Ammonia."

For several years beginning in 1956 he developed and directed what is known as the Farm Progress Show. It began as a large scale experimental project that was carried on in Putnam and Montgomery counties, west of Roachdale, making comparative tests on some 75 to 80 varieties of hybrid corn as to the effects of the various fertilizers and the quality of the various hybrids. Some 30 to 35 farmers cooperated in these experiments by serving as judges of the corn pro-

duced. The project was financed by a large number of hybrid seed corn companies. The Farm Progress Show is still being carried on throughout the corn growing states.

Dr. Hoffer through the years was honored with the Sc.D. degree in 1920 by his Alma Mater, Lebanon Valley College, and with the same degree by Purdue in 1939. He also received the "Distinguished Service Award" from the Society of American Editors.

In 1928 Paul de Kruif devoted Chapter 8 of his book "Hunger Fighters," to Dr. Hoffer, extolling his work as a scientist who had made a fundamental contribution to human welfare.

Dr. Hoffer first joined the Indiana Academy of Science in 1909 and was made a Fellow in 1913. For several years around 1920 he allowed his membership to lapse but he rejoined in 1922 and was again made a Fellow in 1926. He became a member of the American Association for the Advancement of Science in 1917 and a Fellow in 1921. He also had membership in the Society of Plant Physiologists and the Society of Agronomy. Long a member of Sigma Xi, he served as secretary of the Purdue Chapter from 1925 to 1927. He was listed in American Men of Science. For many years he was a member of the Fertilizer Committee of the Soil Science Society of America, the Joint Committee on Fertilizer Application, the Research and Education Committee of the National Fertilizer Association and the Advising Board for the Middle West Soil Improvement Committee.

Dr. Hoffer was a modest, kindly man as well as a patient, persistent, penetrating researcher who was not easily discouraged in probing for nature's secrets. He was recognized not only as an excellent scientist but also a friendly man who enjoyed bowling and golfing with his friends. His memberships in the Masons, Elks, Kiwanis Club, Torch Club, and the Methodist Church attest his civic mindedness.

George Nissley Hoffer will be long remembered as the agricultural scientist who pioneered in the diagnostic studies of the corn plant diseases and the chemical deficiencies in soils leading to those diseases. He pointed the way for scientific methods to be applied to general agriculture. He was one of the greatest agricultural scientists of his generation and a benefactor of mankind.

ROBERT MARVIN JOHNS

Floresville, Texas
March 15, 1928

Bloomington, Indiana
October 21, 1963

In the history of science, literature and other fields one finds the names of men who had the spark of genius but died in early life often leaving behind them imperishable work. One wonders what they might have accomplished had they lived longer. In mathematics one recalls Galois dying at the age of 21, Abel at 27, and in physics Moseley at 27, and others like Keats, Shelley and Brooke in literature. The death of any young artist, poet, scientist or talented individual is to be generally regretted. Such a young scientist was Robert Marvin Johns who

had shown considerable research ability in botany before his death in Bloomington, Indiana, on October 21, 1963, at the age of 35.

Robert Marvin Johns was born on March 15, 1928, in Floresville, Texas. After graduating from Floresville High School in 1944 he spent a year at the University of Texas before entering Baylor University where he received the B.S. degree in 1949. During his last year at Baylor he served as an undergraduate assistant in botany. He accepted a graduate assistantship in botany at the University of North Carolina in 1950 and two years later the M.A. Degree was conferred on him. He remained another year at North Carolina as a Research Assistant in Genetics in the Department of Zoology. The University of Michigan granted him a Teaching Fellowship in 1953 and he spent the next five years at Michigan, serving as an Instructor in Botany during his last year, and received the Ph.D. in Botany and Mycology in 1958. That Fall he came to Indiana University as an Instructor in Botany and was promoted to Assistant Professor in 1960.

He early showed research power, publishing his first paper in 1953 in the Records of the Genetic Society of America. Before coming to Indiana University he published three papers in Mycologia, one of which was a joint paper. While at Indiana University he published a paper in the American Journal of Botany, a joint paper in Mycologia, and an abstract in the Proceedings of the Indiana Academy of Science. Shortly before his death he had completed the manuscript of a paper that was published in Mycologia in 1964. At the time of his death he and two colleagues were preparing the manuscripts of two papers on research related to Physoderma, the completion of which will add much to the understanding of these parasitic fungi.

He was an excellent student, with memberships in Phi Beta Kappa, Phi Kappa Phi and Sigma Xi, and two honorary biological societies, Beta Beta Beta and Phi Sigma. Professionally he was a member of the Botanical Society of America, Mycological Society of America, British Mycological Society, Michigan Academy of Science, Arts and Letters, and the Research Club of the University of Michigan. He joined the Indiana Academy of Science in 1959.

As a teacher he was sympathetic but nevertheless demanded serious effort on the part of his students who respected him for his intellectual integrity and his uncompromising insistence on high standards in work.

Robert Marvin Johns possessed intelligence and perceptiveness much above the average and was recognized as an able young scientist by his Departmental colleagues. Dr. M. H. Rhoades, Chairman of the Department of Botany at Indiana University, wrote "It is a tragedy that the fulfillment of his rich promise will not be realized and that the world is left poorer by his passing. He was in every way a gentleman, a thoroughly likable man, a true scholar."

JAMES FRANCIS MACKELL

Montgomery, Indiana — Terre Haute, Indiana
January 24, 1888 — May 3, 1964

During World War II, in 1943, a bill was introduced in Congress that proposed the annual exchange of 1,000 students from recognized

teachers colleges in the United States with an equal number of students from similar institutions in the Republics of South America. The bill originated and was sponsored by a Committee from the Indiana State Teachers College. This Committee was headed by James F. Mackell working closely with President Ralph Tirey of the College and Congressman Karl Mundt of South Dakota who introduced the bill in Congress. No action was taken on the bill by Congress in 1943, nor later in 1945 when Congressman Mundt reintroduced the bill in a slightly revised form, as is understandable under the war conditions. Chairman Mackell and his sponsoring Committee, which had done much to help prepare the bill and to acquaint other teachers institutions with its proposals, were highly praised by Congressman Mundt for their work on this farsighted measure. Certainly this was a forerunner of much similar legislation later that led to UNESCO and saw over 47,000 students from 131 foreign countries studying in the United States in 1958-1959 and thousands of students from the United States studying abroad.

James Mackell had come to the Indiana State Normal School in 1921 as an Assistant Professor of Physics. Two years later a departmental reorganization was carried out in which the twenty-seven departments of the Normal were reduced through various combinations to thirteen departments. The Departments of Physiology, Physics, Chemistry, Biology, Agriculture, and Geography and Geology were merged into the Science Department with Dr. Louis J. Rettger serving as Dean. At this same time Professor Robert Gillum retired as Head of the Physics Department on account of ill health after serving the Normal School since 1886. In 1924 Professor Mackell was promoted to Associate Professor and three years later to Professor. In 1936 he succeeded Dr. Rettger as Chairman of the Science Department which position he held until 1954 when he retired because of ill health, after 33 years of outstanding teacher training service.

James Francis Mackell was born in Montgomery, Indiana, a small town about 25 miles east of Vincennes. He graduated in 1912 from the old three-year teacher's course at the Normal and taught from 1912 to 1916 in his home town, being Superintendent of Schools. During those years he also completed the requirements for the A.B. degree which he received from the Normal in 1915. In 1916 he became a teacher of physics in Terre Haute Garfield High School and two years later he spent a year as a teaching fellow at the University of California. From 1919 to 1921 he was a graduate student in the University of Minnesota which conferred the M.A. degree on him in 1921. Over the next eleven years he completed the work for the doctorate at Indiana University, receiving the Ph.D. in Physics in 1932.

Dr. Mackell was primarily and at heart a teacher. He was a successful and efficient administrator and also did some creditable research particularly in acoustics and the physics of the atmosphere. He presented his first paper before the Indiana Academy of Science in 1926 on "The Status of Science Education" before the General Meeting. He presented eleven papers before the Academy, four of which were joint papers, and also his President's Address in 1947 on "Graduate De-

grees for College Science Teachers." He also wrote the Academy Memorial for Professor Fred Donaghy in 1938 and the article "Scientists at and from Terre Haute" published in Indiana Scientists in 1951.

He joined the American Association for the Advancement of Science in 1928 and was made a Fellow in 1931. He was also a member of the Association of Physics Teachers, American Association of University Professors, Phi Delta Kappa and Sigma Xi, and was listed in American Men of Science. He joined the Indiana Academy of Science in 1925, became a Fellow in 1929 and its President in 1947. He was also a member of the Elks and of the Terre Haute Literary Club.

Dr. Mackell was very active in the Academy in his later years, serving on various committees, the last being the Fellows Committee from 1953 to 1957. He was Chairman of the Program Committee in 1939 and 1946, the years in which the Academy met in Terre Haute. He was always alert to be of service and was most accommodating and conscientious in his work.

During the last years of his life he suffered ill health and following the death of his wife he became a resident of the Terre Haute House where he passed away on May 3, 1964. With the death of James Mackell the State of Indiana lost an outstanding educator and in the Academy of Science he will long be remembered as one of its most faithful and active members.

ALLAN CHARLES GRAY MITCHELL

Houston, Texas — Bloomington, Indiana
October 1, 1902 — November 7, 1963

The year 1937 was a critical year for the Department of Physics at Indiana University for it saw the retirement of Professor Arthur L. Foley, Head of the Department since 1897, and the death of Professor

John B. Dutcher in July, which left only two ranking members in the Department, Professor Rolla B. Ramsey and Associate Professor Mason E. Hufford. The situation was further complicated by the facts that Professor Ramsay was nearing the retirement age and President William Lowe Bryan was retiring. President Bryan was succeeded by Dr. Herman B Wells in early 1938.

Following his acceptance of the presidency Dr. Wells immediately set about reorganizing and modernizing the Physics Department by appointing the internationally known physicist, Allan C. G. Mitchell, to the headship, and arranging for the building of the then second largest cyclotron in the United States so that nuclear research could be carried on. Dr. Mitchell resigned the chairmanship of the Department of Physics at New York University to come to Indiana University.

Allan C. G. Mitchell was born in Houston, Texas, October 1, 1902, and died suddenly of a heart attack in Bloomington, Indiana, on November 7, 1963. He was the son of Samuel A. Mitchell, internationally known astronomer and Director of McCormick Observatory, University of Virginia, for 32 years and noted for his work as astronomer on ten eclipse expeditions, on some of which his son accompanied him. Allan Mitchell received his B.S. degree in 1923 at the University of Virginia, and the M.S. the following year, serving as an assistant during his last four years at the University. He spent the next three years at California Institute of Technology as a Teaching Fellow and received the Ph.D. in Physical Chemistry in 1927. He followed this with a year of nuclear study in Germany at the Universities of Munich and Gottingen. From 1928 to 1931 he was a Fellow in the Bartol Research Foundation Institute where he made a reputation as an outstanding research physicist. In 1931 he accepted an assistant professorship in Physics in New York University and three years later he was promoted to Associate Professor and made Chairman of the Department.

Dr. Mitchell brought with him to Indiana University Drs. Emil J. Konopinski and Lawrence M. Langer who during the next few years were to play prominent roles in the development of the atom bomb and subsequently the hydrogen bomb. Also a specialist on cyclotrons, Dr. Franz N. D. Kurie, was secured to take charge of the cyclotron. Indiana University through the work of Mitchell, Konopinski, Langer and Kurie was destined to become a leading research center in nuclear physics.

Dr. Mitchell hardly had time to reorganize the Department before Hahn and Strassman, in Germany, announced in February, 1939, the breaking up of the uranium atom through slow neutron bombardment and the producing of barium. Lise Meitner, a German Jew refugee in Denmark, almost immediately guessed and recognized the result of this experiment as "fission" of the uranium atom, producing barium and krypton. This experiment also resulted in the famous Einstein letter in 1939 to President Roosevelt pointing out the fundamental nature of the result and the possible dangers to the free world. President Roosevelt in the Fall of 1939 appointed an "Advisory Committee on Uranium" and the atom race began.

With the beginning of World War II in 1939 the great research centers at California and Massachusetts Institutes of Technology, the University of Chicago and other universities quickened their nuclear studies. Dr. Mitchell became a Research Associate at Massachusetts Institute of Technology in 1940. Because of its cyclotron Indiana University early began research work with Dr Mitchell as Director, first under the sponsorship of the National Office of Scientific Research and Development and later from 1942 to 1944 as a branch of the comprehensive but largely secret "The Manhattan Engineer District" project which included numerous laboratories and employed most of the physicists of the United States and England. From January to August, 1942, Dr. Mitchell commuted from Bloomington to Chicago to work on preliminary experiments in the Chicago Metallurgical Laboratory which resulted in the famous Stagg Field Squash Court experiment on December 2, 1942, that proved that a nuclear chain reaction could be controlled. From 1944 to 1946 he was associated with the Applied Physics Laboratory of Johns Hopkins University where his knowledge and administrative ability were used in research on the development of guided missiles and aircraft directors. He received the Naval Ordnance Development Award for his work at Johns Hopkins. During all these years Drs. Konopinski and Langer were absent from Indiana University engaged in war work. Following the close of the War Dr. Mitchell continued as a consultant in government research projects such as the Project Vista of California Institute of Technology in 1951.

However, before war work seriously interfered, extensive nuclear research studies using the cyclotron were carried on by the Physics Department at Indiana University. At the General Meeting of the Academy in 1939 Professors Mitchell, Langer, Konopinski, Kurie and Hufford and several of their graduate students presented six of the eight papers given before the Physics Division. Two years later Professors Mitchell, Langer and Konopinski presented papers for the last time to the Academy until after the close of the War, although Professors Ramsey and Hufford continued to present and publish papers. Nevertheless about a dozen doctorates in Physics were conferred by the University from 1938 to 1945.

Following the resignation of Professor Kurie in 1946, Dr. Mitchell brought in Dr. M. B. Sampson to take charge of the cyclotron, and Dr. R. G. Wilkinson, a specialist in nuclear spectroscopy, who had been a member of the Metallurgical Laboratory staff in 1942 at Chicago. Drs. Konopinski and Langer also returned to Indiana University from the Los Alamos Laboratories. With this excellent group of researchers and the addition later of younger scientists, the Physics Department despite World War II conferred a total of 92 Ph.D. degrees and 119 Master's degrees during the 25-year period from 1938 to 1963 under the administration of Dr. Mitchell.

In 1943 Dr. Mitchell became a starred scientist. He was a Fellow of the American Physical Society, served on its Council from 1943 to 1947, and was Associate Editor of the Physical Review from 1941 to 1944. Earlier he had served from 1932 to 1934 as an associate editor of the Journal of Chemical Physics. He joined the American Associa-

tion for the Advancement of Science in 1925 as a Life Member and was made a Fellow in 1931. He served on the Board of Governors of the Argonne National Laboratory from 1949 to 1956. At the time of his death he had just completed his third term as President of the Midwestern Universities Research Association organized to develop a great research center in the Midwest to be equipped with a giant accelerator for the use of midwestern universities. Dr. Mitchell was also a member of Phi Beta Kappa, Sigma Xi, Alpha Chi Sigma and Beta Theta Pi.

He was the author of numerous research papers on nuclear physics published in the leading journals of physics. In 1934 he and M. W. Zemansky published a book on "Resonance Radiation and Excited Atoms." Since excited atoms are fundamental in the development of masers and lasers, so important in the control and use of light, infrared radiation and microwaves for communications programs on earth and in space, this book has been recently republished and also translated into Russian. He was also author of chapters in "Beta and Gamma Ray Spectroscopy," published in 1955.

Dr. Mitchell had an international reputation as a nuclear physicist and was long listed in Who's Who in America and American Men of Science, and in Who's Who in Atoms recently published in London.

He joined the Indiana Academy of Science in 1938 and was made a Fellow in 1954. In 1955 he became a member of the Academy Fellow Committee and served until his death. Before and after World War II he maintained an active interest in the Academy by presenting papers and encouraging members of his staff and graduate students in physics to do likewise.

The State of Indiana, Indiana University and the Indiana Academy of Science owe much to this outstanding scientist and administrator whom the future years will recognize as a Giant in the science of These Days.

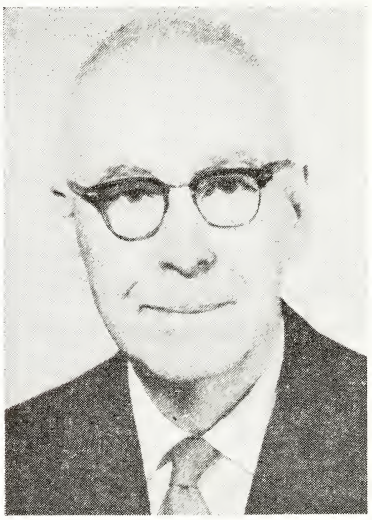
TRUMAN GEORGE YUNCKER

Carson City, Michigan
March 20, 1891

Greencastle, Indiana
January 8, 1964

It is somewhat unusual to find a scientist with an international reputation in his field of science who has spent his whole professional life as an active member of the Faculty of a smaller college or university. A relatively heavy teaching load, lack of sufficient library and laboratory facilities, and free time to be active in scientific circles and meetings almost preclude such a possibility. However, Truman George Yuncker was such a scientist for he was an active member of the DePauw University Faculty for 37 years and following his retirement in 1956 still continued as Curator of the Herbarium when he was not on a research mission to some tropical area. DePauw University early recognized his talents and freely granted him leaves of absence so that he could pursue his scientific studies that could not be carried on during summers. This was possible because he had faithful and professionally

competent colleagues, all his own majors during his last 25 active years, who took over his course work during his absences. Also his wife was an able, scientific collaborator who frequently accompanied him on his extended travels and who, during the year 1932-1933, served as Acting Professor of Botany while he was on leave in Hawaii as a Yale Bishop Museum Fellow. He was the author of over 135 publications: books, research papers, memorials, presidential addresses, expository articles, and reports.



Truman George Yuncker was born on a farm near Carson City, Michigan, on March 20, 1891. A few years later his family moved to Lansing. When he was of high school age, because of family finances, he had to work and never attended high school. However, after his day's work he attended night courses in a business college which prepared him for secretarial work. In those days it was not uncommon for colleges to admit promising, mature students who were not high school graduates and, with improved conditions, Yuncker was admitted to Michigan State College and was graduated in 1914 with a B.S. degree.

While at Michigan State he worked under the botanist, Ernest A. Bessey, a graduate of the University of Nebraska, whose father, Charles E. Bessey, had been Professor of Botany at the University of Nebraska since 1884. Following his graduation Yuncker went to Nebraska as an assistant in Botany and received the M.A. degree in 1915. While he was there Professor Charles E. Bessey died and was succeeded by his colleague, Raymond J. Pool, as Professor and Head of the Department, under whom Yuncker worked. He spent the year 1915-16 as a botany teacher in Manual Training High School in Indianapolis. In 1916 he accepted an assistantship in botany at the University of Illinois, to work under Professor William Trelease, a botanist of international reputation and the first President of the Botanical Society of America.

However, Yuncker spent part of the year 1918 as a bacteriologist in the U.S. Army Medical Corps, in Washington, working on research and production of vaccines. He returned to the University of Illinois as a Fellow in Botany and received the Ph.D. degree in 1919. His thesis was on the botanical genus Cuscuta and was directed by Professor Trelease.

Dr. Yuncker came to DePauw University in September, 1919, as an Assistant Professor of Biology, was promoted to Associate Professor the next year. In 1921 he was made Professor of Botany. Botany was set up definitely as a distinct department in 1928 with Professor Yuncker as Head, which position he held until his retirement in 1956. While he regularly offered courses each year in bacteriology it was not until 1947 that a definite program for a major was offered in the Department and the name was changed to the Department of Botany and Bacteriology. The first major in bacteriology was graduated in 1948 and during his last nine years before his retirement 43 of the 57 graduates in his Department majored in bacteriology. Also during his last eleven years as Head of the Department he directed the work of six candidates for the M.A. degree, three in botany and three in bacteriology.

Dr. Yuncker's research was done in the taxonomy of the genera Cuscuta, Peperomia and Piper, the latter two genera in the family Piperaceae, tropical plants having aromatic herbage. The genus Piper was the special field of interest of Dr. Trelease and before his death in 1945 he requested that his former pupil, Dr. Yuncker, who had also specialized in the genus Peperomia, revise and bring up to date the taxonomy of the Piperaceae or pepper plants, using Dr. Trelease's notes and other materials. Granted a research professorship by the University of Illinois, Dr. and Mrs. Yuncker spent the year 1946-47 on this work which resulted in the publication in 1950 by the University of Illinois Press of two volumes, "The Piperaceae of Northern South America," containing 838 pages and 674 plates, describing 800 species of plants of the pepper family, half of which had never before been scientifically identified and described. The books were published under the joint authorship of Professors Trelease and Yuncker and undoubtedly will long be a classic and an authentic reference work on Piperaceae.

In 1919 Dr. Yuncker joined the Indiana Academy of Science and was made a Fellow in 1923. He presented his first paper, "Notes on our Indiana Dodders," before the Academy in 1919, which was published in the Proceedings for that year. Dodders, or the genus Cuscuta, are a large and widely distributed genus of twining, leafless, parasitic herbs, and Dr. Yuncker early became an authority on Cuscuta, publishing numerous papers, treatises and revisions of previously published reports as new species were discovered. His researches on the genus Peperomia likewise resulted in numerous papers and reports.

In 1930 the Fifth International Botanical Congress met at Cambridge, England. Professors J. C. Arthur, D. M. Mottier, M. S. Markle, and their wives, and Professor Yuncker all attended this Congress. Professors Arthur and Mottier were then Past Presidents of the Indiana

Academy of Science and Professors Yuncker and Markle later became Presidents of the Academy. During the next 32 years Dr. Yuncker spent various periods of time from summers to a year's leaves of absence in the United States, Canada, Europe, Hawaii (1932-33), (1939-40), Hondurus (1934, 1936, 1938), Cuba (1948), Samoa and Niue (1939-40), Tongan Islands (1953), Jamaica (1957-58), Brazil 1962. And while at home he received collections from other parts of the world which he identified and described and which enabled him to publish papers on new species of Cuscuta and Piperaceae found in Argentine, Bolivia, Chile, Ecuador, Panama, Peru and Venezuela, and other parts of the world such as Fiji, South Africa, and Nepal.

His research reputation led to Dr. Yuncker being made an Honorary Associate Botanist of the B. P. Bishop Museum of Hawaii from 1941 to 1964. He was the recipient of two Yale-Bishop Museum Fellowships in Honolulu, two Guggenheim Fellowships, three National Science Foundation grants, a Fulbright Fellowship and a grant from the American Philosophical Society. His Alma Mater, Michigan State, honored him with the Sc.D. degree in 1941 and the Distinguished Alumni Award in 1959.

While he was on a research project in Brazil in 1962 he was injured by an automobile in Rio de Janeiro and forced to come home. While not seriously injured, he never recovered and in February, 1963, he suffered a coronary heart attack. He recovered sufficiently, however, to work with his wife and his faithful departmental colleague, Dr. Winona Welch, in the preparation of the manuscript on Brazilian Piperaceae, which was in the process of publication at the time of his death in his sleep on January 8, 1964.

Dr. Yuncker became a member of the American Association for the Advancement of Science in 1921 and was made a Fellow in 1925. He served the Botanical Society of America as treasurer from 1947 to 1952, vice president in 1953 and chairman of the Taxonomy section in 1937, and received its Golden Anniversary Certificate of Merit in 1956. He was a member of the American Society of Naturalists, Society of American Bacteriologists, Torrey Botanical Club, American Legion, Sigma Xi, Phi Delta Theta, and Scabbard and Blade. He was President of the Society of Plant Taxonomists in 1957.

He was an active 32° Mason, a member of the Scottish Rite, and a Grand Patron of the Indiana Chapter of the Order of Eastern Star. Long a member of the Greencastle Kiwanis Club, he served as its President in 1943. He served the City of Greencastle as its Forester for many years. An active churchman, he had held various offices in the Greencastle Gobin Methodist Episcopal Church.

For six years preceding his retirement he lectured at the Methodist Hospital in Indianapolis on Microbiology to student nurses as a part of DePauw's School of Nursing program. After his retirement he continued his work as Curator of the Truman G. Yuncker Herbarium, named in his honor, for he had begun this service as Curator in 1919 when the herbarium consisted of approximately a thousand sheets and he had developed it to 125,000 sheets. Also he had built up the Botanical Library into a comprehensive source of botanical literature.

He was an effective teacher, a wise administrator, a gracious host, and a fine citizen. He possessed that quality of personality that inspired his student majors to continue their studies after graduation. This is evident in the studies made of the college origins of persons who obtained Ph.D. degrees in botany in the decade from 1936 to 1945, and the fifteen-year period from 1936 to 1950. In the decade period DePauw had 11 graduates who received the Ph.D. degree in Botany while no other college or university in the State had more than nine. The fifteen-year period study showed DePauw still leading with 14 graduates getting the Ph.D. in Botany with the institution ranking second in the State having ten such graduates, and DePauw ranked third in the United States among the private universities, being exceeded only by the University of Chicago and Harvard.

Truman G. Yuncker was one of the most productive and faithful members in the history of the Indiana Academy of Science. He was Vice President in both 1931 and 1938 and President in 1939. Over the years he had served on various important Committees such as the Committee on the Junior Academy, 1943-47, Program, 1941, 1957, Chairman of the Research Grant, 1945-64, and others. He presented numerous papers before the Academy in Botany, Bacteriology, and the History of Science, most of which were published in the Proceedings.

Future generations of Indiana scientists will consider Truman George Yuncker as one of the scientific Giants of these Days.

PRESIDENTIAL ADDRESS

Johnny and Relativity

EDWARD L. HAENISCH, Wabash College

My title for tonight is a "come-on" for a discussion of science education, particularly at the elementary and junior high school level. Actually before I am finished I will discuss what to me is an exciting experiment in the teaching of the concept of relativity to school children.

I can personally recall a number of dismal experiences with elementary school science. Shortly after the Russians launched Sputnik 1, I was closely involved in one of the Crawfordsville P.T.A.'s. We bought for the Willson School a kit for science laboratory demonstration. As far as I know, it was mostly unused and was probably discarded when the old building was recently wrecked.

One night when my daughter was still a student at this school, she started the conversation at the dinner table with the question, "Daddy, do you know that there are three isotopes of hydrogen?" I admitted that this bit of knowledge was part of my store of factual information. I countered with the question, "What is an isotope?" She replied, "I don't know, but hydrogen has three of them." I went on to find out that she was full of such pieces of information but she was without understanding.

During my year in Washington in 1958-59, one of my jobs with the National Science Foundation was to distribute funds for the first summer institutes for elementary school teachers. I remember to my dismay when I visited one of these and found that the lesson for the day was on how to make the sound of the jungle animals. It was a disillusioning experience to see prospective science teachers learning how to roar like a lion.

All of us are aware of the vast improvement in the graduates of our high schools. Consider mathematics. Ten years ago at Wabash hardly anyone had more secondary school preparation than a year of algebra and a year of plane geometry. Today it is unusual if our entering freshmen have not had four or even five years of high school mathematics. Many of them have had calculus. Last September one or two started in differential equations.

Back in 1952 the Advanced Placement Program started. This is a plan whereby college work is presented in high school. It has accelerated rapidly. It is more important in eastern institutions than here in the midwest. It is my understanding that over half the class entering Harvard achieve sophomore status.

High school science has improved enormously. With the support of the Course Content Improvement Section of the National Science

Foundation, the new phenomenon of "committee writing" has developed. Through the cooperation between research workers, college and university teachers, experts in movie production, scientific illustrators, etc., we have such outstanding high school courses as the Chemical Education Material Study (CHEMS) and the Chemical Bond Approach Project (CBA); Physical Science Study Committee physics (PSSC); the mathematics courses prepared by the School Mathematic Study Group (SMSG), the University of Illinois Committee on School Mathematics (UICSM), and others; and the three biology courses with distinctly different approaches developed by the Biological Science Curriculum Study (BSCS). All these projects and dozens of others are described in a NSF publication. (1)

It is interesting to notice the tremendous and rapid impact these courses have had. PSSC physics started in 1956. During 1964-65 almost 40%, or 160,000 of the high school students taking physics are using these materials. CHEMS started in 1959, and in 1964-65 about 20%, or 220,000 high school students taking chemistry are using these materials.

Most important among the results of these high school science courses are: 1) the emphasis on the importance of experimental observation and deductions therefrom; 2) a decrease in the amount of memorization; and 3) the emphasis upon "models" (conceptual schemes) and their role in the development of science.

Lately the National Science Foundation has been giving much financial support to science instruction above and below the high school level. There are such things as the College Commission on Physics (CCP) and the Committee on Undergraduate Programs in Mathematics (CUPM). I am a member of the Advisory Council on College Chemistry (AC_3) and its Editor. Another former Academy president, Willis Johnson, is an active member of the Committee on Undergraduate Education in the Biological Sciences (CUEBS). The work of these college and university oriented groups are also summarized in the previously mentioned NSF pamphlet. (1)

Below the high school level the Foundation is supporting many studies for the elementary and junior high schools. (1) It is about these that I want to tell you.

One of the leaders in the elementary science development has been Professor Robert Karplus of the University of California at Berkeley. He points out that the most significant thing in presenting science to the elementary student is the teacher's attitude. Scientific concepts are not to be introduced in an authoritarian fashion. The teachers are supposed to furnish experimental evidence that will be truly convincing and acceptable to the pupils. If we think about this, and the scientific background of most of our present teachers, we realize what a dilemna is facing us in education in science in the elementary schools. Many of our teachers have not performed a single experiment in their college science courses.

There is an organization known as Educational Services, Incorporated, which has prospered from some of the profits of PSSC physics. (2) It is currently one of the strong centers in developing elementary

science education. Let me tell you about one of their products, an experiment called "Mystery Powders—An Introduction to Analytical Chemistry."

This is an experiment planned for fourth graders. It deals with five white powders: starch, baking soda, powdered sugar, boric acid and plaster of Paris. Each of these can be identified by a rather specific test—sugar, for example, by its taste or by its carmelization as it is heated; or plaster of Paris by its hardening when moistened and then dried. After studying the identifying tests the students are asked to devise methods of analyzing any possible mixture of the five powders.

More important than the details of the tests is the set of suggestions offered to teachers who use the experiment. Let me read them to you. I have added a few parenthetical remarks to help you grasp a few of the tests which may be unfamiliar.

"Do all of the experiments yourself. Add your observations to the discussions. 'When I did it, mine turned yellow.' Pretend you don't know what the powders are and that you are trying to find out with your kids. It may be that a teacher who really didn't know what the powders were would be able to teach this material better. Be enthusiastic. Look with excitement at what the children do. Jump up and down over a blackened spoon (over-carmelized sugar) or a tiny lump of hardened powder (dried plaster of Paris).

"There are no absolutely correct answers. Don't characterize an answer as right or wrong. The identification of the mystery powders should be based upon the results of the experiments. Even if you know that there is no starch in a particular mixture and a preponderance of observations show a black color with iodine (this is a test for starch which I did not discuss), the conclusion should be that starch is present. Remember that the correct determination of the powders is unimportant (except to the students), and is used only as a means to get the children to act and think as we would like.

"Teaching by the 'discovery method' is very time-consuming. You spend a lot of time without apparently accomplishing anything. But learning is a slow process. There must be time to 'fool around,' time to make mistakes, time to try something over and over again, and time to think. Don't worry about things moving too slowly. If the children are doing science and thinking science, they are learning."

Now we come to the topic set out by my title. This is one of the developments of Dr. Karplus whom I mentioned earlier. He is the Director of the Science Curriculum Improvement Study Center at the University of California at Berkeley. Here is one of his books, "Relativity of Position and Motion." (3) Notice on the cover the teacher pointing to "Mr. O." Now most of you would think that relativity is a topic probably reserved for graduate school. When I was in high school back in the twenties the apocryphal story was circulating that there were less than a dozen scientists in the world who understood what Albert Einstein had written about relativity in 1905. We do talk a lot about relativity to the Wabash undergraduates and even have a large section on relativity in the physics-chemistry

course for the non-science major. As of now, however, we do not count on our students having the background in relativity that I'm going to tell you about.

First of all, let us talk about "Mr. O." Here is what Karplus (3) has to say about this fictitious puppet which he and his associates have invented to help elementary school children understand relativity of position and motion.

"* * * we have created an artificial observer whom we call Mr. O. Mr. O directs his attention to the objects in the system of our choice. At all times he knows where every object is, but he always describes the location of everything relative to himself. Also, he never wonders 'why'—why events happen, or why objects appear the way they do. He reports in his egocentric way only what can be observed and what does happen.

"If, for example, a Mr. O on a table were asked, 'Where are you?' he could only answer, 'I am right here,' perhaps while pointing to himself. If he were asked, 'Where is the table?' he would say, 'Underneath my feet.' To the pupils in a class, of course, Mr. O would be on the table. Such a point of view, however, subordinates Mr. O to the table. For Mr. O, he himself is the central reference point. The way he faces defines the reference directions such as right, left, up, down, front, and back. Such a reference point, together with reference directions, is called a reference frame. In other words, Mr. O makes concrete the idea of a reference frame.

"Is Mr. O like a real person? No, of course not. Since he has no senses, he cannot be limited to the use of his own senses. His characteristics are created to help the teaching program and not to make him resemble a person. In his 'reports' he summarizes all the knowledge of the person who uses the Mr. O concept. He does not have to depend on his vision or on his hearing to detect what happens. Objects that block light or sound, therefore, do not interfere with his 'observations.'

"Despite Mr. O's rather unusual characteristics, three examples will show that everyone's common-sense outlook makes use of the Mr. O concept, even if he is not aware of this.

"Example 1. Mother drives her daughter to school. The girl starts to climb into the back seat. 'Don't move around so much. Sit still,' mother says. The daughter obeys. That satisfies mother. But is daughter really not moving? That depends. To a Mr. O in the car, she is indeed sitting still. To a Mr. O on the sidewalk, however, the car, the mother, and the daughter are moving past at perhaps 30 mph. Mother automatically uses both of these Mr. O's: one inside the car when she thinks about her daughter's behavior, and one on the sidewalk when she thinks about the car as a whole.

"Example 2. In a bus, the situation is still more interesting. As the bus starts suddenly, the passengers seem to fall backwards. Do they really fall backwards? Not to a Mr. O on the road; to him, they are moving forward, but more slowly than the bus. To a Mr. O on the bus, of course, they do move backwards. Who is right?

"Example 3. In astronomy, everyone learns that the earth rotates on its axis and moves around the sun. Is this true? To an observer

on the sun, it is. But to an observer on the earth, the earth doesn't move at all; it is fixed beneath his feet. To him, the sun and moon move around the earth and show certain seasonal variations. Which idea is right?

"These examples suggest that the concept of motion of an object is not an absolute one. Like the concept of position, it makes sense only when it is related to a certain reference frame, such as a Mr. O. The reference frame may be selected consciously or unconsciously. In the common-sense view, motion is usually seen relative to the reference frame provided by the immediate physical surroundings of the object of interest. Thus, the daughter is seen relative to the automobile interior, the automobile relative to the road, the road relative to the surrounding countryside, the countryside relative to the whole earth, the earth relative to the sun, the sun relative to our galaxy, and our galaxy relative to the system of galaxies called the universe. To avoid confusion and misunderstanding, the children will use Mr. O as the reference frame instead of using the physical surroundings."

Perhaps the significance of "Mr. O" will become more obvious to you as we talk about a story that Dr. Karplus has prepared for the elementary children. It is entitled "Joey, Spots and the Wagon." You can see that it is illustrated like a first or second grade reader, and it reads like one.

"Joey lived on a farm.

Joey liked to play with his dog Spots and with his wagon.

He liked to ride in the wagon while Spots pulled it along.

Then he felt so good he thought just about Spots, the wagon, and himself.

Spots, the wagon, and Joey himself were the only objects in the system about which Joey thought."

The rest of the tale is one based on misunderstanding which arises when the reference frame is not specified. Here is a synopsis:

"Joe goes for a ride one day in his wagon. Spots pull them, into a forest, and they get lost. Mother looks for Joe, and she calls him when she can't find him. 'Joe. Joe. Where are you?' Joe answers, 'Here I am, in my wagon!' Was that right? Yes, it was exactly right. His mother replies, 'You stay where you are. I'm coming after you. Don't move.' Joe, who is a good boy, stays right where he is in the wagon, but Spots, who can't understand words, keeps on walking. Did Joe obey his mother? Yes, he did, he didn't move at all. After a while his mother calls again, 'Joe where are you? I told you to stay where you were! And Joe answers, 'I'm right here in my wagon where I was before . . . ! Eventually, the wagon hits a rock and tips over. Joe's daydream is shattered. He hears his mother calling him again, 'Joe, where are you?' This time Joe answers, 'I am next to the largest tree in the forest,' and his mother soon finds him.

"Children, who are very often literal, understand and enjoy the misunderstanding between Joe and his mother."

Now I hope that even the least scientific among you has some idea of what is meant when we talk about "frame of reference."

Now that you have heard the story of Joey and Spots and seen how Dr. Karplus works with the children, you might be very interested in Dr. Karplus' advice to science teachers.

"In all this work, encourage the children to report their observations frankly. They should describe what they see, hear, feel, smell, and so on. Accept a variety of descriptions, even if they appear to contradict one another. Then look for a resolution of the disagreements by letting the children recognize that they were thinking like different Mr. O's. The children should not get the idea that you expect a certain special answer; if they do, they will give you that answer and stop making observations. For this reason, we should like you to ask, 'What have you observed today?' Then each child can give an honest answer. Some teachers ask 'What have we learned today?' This question causes pupils to try to remember what they were supposed to have learned. They will repeat the teacher's statement of the lesson's objective and will stop analyzing their observations independently. It is very hard for the children to know what they did learn.

"Let us now discuss the tendency of teachers of science to try to tie things up in a neat package every time a new experiment is performed. At the end of the period, many teachers feel they should summarize what has happened during that period. This is such a common tendency among teachers that we have given it a name, Lysiphobia—the fear of leaving 'loose ends.' If you have this common malady, you will find it hard to resist the temptation to summarize. Nevertheless, try. Leave some loose ends. These you and the children will pick up during some future experiments. The children's recognition that the old and the new experiments are related is a discovery which will thrill them and increase their interest."

The Commission on Science Education of the American Association for the Advancement of Science has prepared an elementary science program which emphasizes the processes utilized in scientific investigation. (4) In kindergarten through third grade the following processes are emphasized:

Recognizing space/time relations
Recognizing number relations
Observing
Classifying
Measuring
Communicating
Inferring
Predicting

It is interesting to note that arithmetic and mathematics is naurally included in the science course. First experiments in mensuraton are done in arbitrary units, and then the metric systems is used in preference to the English system.

In the fourth and fifth grades the experiments are designed to include the additional processes of:

Formulating hypotheses
Making operational definitions
Controlling and manipulating variables
Experimenting
Formulating models
Interpreting data.

I wish that time permitted a detailed description of some of the first teaching units such as emphasis on observation by perception of colors by kindergartners or emphasis on measurement by first graders using "rulers" of arbitrary length to report the length of a table as between 7 and 8 "blips." The necessity of such a result leads to the early introduction (second grade) of the notion of fractions. Would you be surprised to learn that the fourth teaching unit (used with kindergarten children) has as its object the process of observation and as its title—"Sets and Their Members?" Among the materials needed to teach this unit are: party hat (cone shaped) solid rubber ball, metal pipe or rolling pin, Christmas tree ornament (sphere shaped), cube of sugar, funnel, picture of Egyptian pyramid. Sounds interesting, doesn't it?

I could go on with many descriptions of other elementary science projects. Dr. Karplus' study includes a unit on entropy (that awe-inspiring word associated with the second law of thermodynamics). (5) Professional astronomers and science education specialists at the University of Illinois have cooperated with elementary teachers to develop a course on basic astronomical themes and relying heavily on mathematics, physics and chemistry. (1) "Time, Space and Matter: Investigating the Physical World," is the title of a junior high school science project under development at Princeton University. (1)

To me, one of the significant things in these courses for elementary and junior high schools is the lack of lines of demarcation between the various sciences. Science is a natural enterprise growing out of experimentation and not full of foreboding boundaries. The major research achievements of our time have been in the inter disciplinary fields—biochemistry (molecular biology), space, nuclear energy—to mention a few. Perhaps there is here important implications as to the way science ought to be taught at advanced levels.

Before I conclude let me ride one of my pet "hobby-horses"—the order in which we teach the various sciences, especially in high school. The traditional parade of biology,—chemistry—physics has been based on an order of difficulty of the material. Think about it in terms of the background required for understanding modern developments. Chemistry is based on physics. Biology, especially the rapidly expanding and exciting field of molecular biology, is based on chemical principles and knowledge of organic chemistry. Why can't we change the order to physics—chemistry—biology or perhaps, even better, consider inter-disciplinary courses.

I hope I have conveyed to you a sense of the excitement and revolution in the air today concerning science teaching. There is much change and experimentation ahead. Everyone of us here tonight should be interested and play a part in the upheaval. The Indiana Academy of Science should also do its share. I personally am grateful to be a science teacher at this time..

Literature Cited

1. NSF Publication 64-8. 1964. Science course improvement projects. (Available from U. S. Government Printing Office).
2. Review of Current Programs, 1965. Educational Services, Inc., 108 Water St., Watertown, Mass., 02172.
3. Karplus, Robert. 1964. Relativity of position and motion. Science Curriculum Improvement Study, University of California, Berkeley 4, Calif.
4. AAAS Commission on Science Education. 1964. Science—a process approach. American Association for the Advancement of Science.
5. Karplus, Robert. 1964. One physicist looks at science education. Science Curriculum Improvement Study.

ANTHROPOLOGY

Chairman: WESLEY R. HURT, Indiana University

KING BURTON HUNTER, Indiana University, was elected chairman for 1965

The Sacrum of the American Indian

ALLAN L. URBONT, Indiana University

Introduction

This paper represents an interim report on research in progress on the variability of the human sacrum, with regard to phylogenetic history, racial, developmental, age, sexual and constitutional characteristics. I would like to confine myself to a few general remarks and a brief discussion of the interrelationship of various aspects of the sacrum, with special reference to be placed upon the expected findings concerning a series of prehistoric American Indians of the Middle Mississippi culture of the Middle West. Since the study has only been recently initiated, most of the conclusions drawn at this time will be tentative and remain to be substantiated quantitatively in a future paper. Nevertheless, a number of conclusions which seem to reflect obvious trends are offered here.

Evolutionary and Phylogenetic Interest

Of all the bones of the vertebral column, it is especially the sacrum that evokes continued interest because of its evolutionary role in the functional changes of the pelvis; changes exemplified by the primitive mammals becoming viviparous, and the assumption of upright gait in the early hominids.

The phylogenetic interest in the sacrum centers around a study of morphological variability in prehistoric and present varieties, or biological populations, of man. The interest therein being the determination of the qualitative and quantitative significance of the retention of ancient characteristics that reflect the history of various evolutionary lines. Thus, variations in the number of sacral vertebrae represent problems in segmentation that extend back to primitive vertebrates. Sacral segments, for example, are normally five in number. They may, however, vary from four to six. Transitional forms also exist wherein there is a lumbarization of the first sacral vertebra. Other characteristics that reflect the history of various evolutionary lines are the following: development of the pelvic girdle, which extends back to the early amphibians who emerged from the sea; stabilization of the pelvic girdle for terrestrial locomotion and support, extends back to the primitive reptiles; the changes from oviparous to viviparous repro-

duction, which involved a widening of the pelvic inlet to allow for the passage of the foetal head, extend back to the early mammals; the adaptations from a terrestial to arboreal locomotion, extend back to the early primates; and finally, with the shift back to the ground and upright gait, we reach the early hominids.

Sexual Differences

It is obvious that a complex structure with multiple functions, such as the entire pelvic girdle, reflects the interplay of many mutational, adaptive and functional factors. Thus, with an increase in the gestation period in higher mammals, and the assumption of a bipedal form of locomotion, a number of adjustments had to be made. With a widening of the pelvic inlet, in which a transverse broadening of the sacrum is involved, there is a weakening of the sacro-iliac joint in the female. In order to compensate for the lesser involvement of fewer sacral elements in the joint, some of the ligaments become heavier. This is so in the case of the inferior sacro-iliac ligament, which found a firmer attachment through the development of a pre-auricular sulcus, in the female. In the male, the facet of the sacro-iliac articulation may

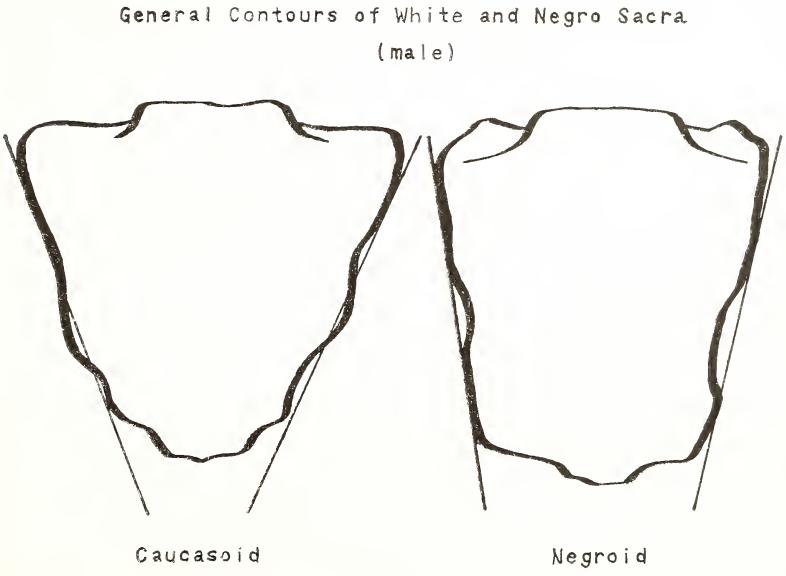


Figure 1. White and negro sacra.

involve from three to three-and-a-half sacral vertebrae in length, as contrasted with the two-and-a-half to three which are usually involved in the female. This particular trait, however, may exhibit significant or non-significant differences per population. Trotter, for example, found no sexual differentiation in the extent of the articular surface in a

sample of Ancient Egyptian sacra. Further sexual differences include a shorter and more proportionately broader sacrum, with a more marked sacro-vertebral angle in the female. The female sacrum is more obliquely set than in the male. Generally, the sacral curve is more uniform in the male throughout its entire length, whereas the female sacrum tends to be flatter above, and more accentuated below.

Racial Differences

Racial differences also exist, to a greater or lesser degree, as may be demonstrated by the following generalizations made between the Caucasoid and Negroid sacrum, (Fig. 1). The sides of the Negroid sacrum are noticeably more parallel than the more slanted Caucasoid sacrum. Thus, if lines were to be drawn along the lateral aspects of the sacra, a lesser angle would be obtained for the Negroid specimens as compared to the Caucasoid samples. In addition, the Negroid sacrum is longer in proportion to breadth, with less promontory, and narrower alae than the Caucasoid sacrum. There also appears to be a greater downward slant of the alae in the Negroid sacrum.

As per Radlauer, racial differences were found for a series of twenty characteristics, consisting of indices and angles. By drawing a horizontal axis which represents the mean value, and with fluctuations on each side of the horizontal, Radlauer graphically indicates the position of Mongoloid groups to other, non-Mongoloid groups, and the position of South American Indian groups to other Mongoloid varieties. In this way, a number of continuous variations may be assessed at a glance. Of the fourteen indices, (six of the twenty characteristics had no data for Asiatics), in five cases the means of the South American Indian series are closer to those of Asiatic series such as Malays, Burmese, Chinese, Japanese, than they are to the means of Europeans. In six cases, the reverse is true, whereas in three indices, the values for South American Indians, Asiatics, and Europeans are nearly identical.

The above data, in which only a number of South American Indians and Asiatic series are lumped, can therefore only at best serve as a rough indication of the intermediate position of South American Indians between Europeans and Asiatics. Additional data in which a number of biological populations on a varietal level are compared, may reveal more historically meaningful results. This may especially be so in the contrasting of North American Paleo-Amerind with Paleo-Asiatic, and North American Ceno-Amerind with later Mongoloid varieties. A comparison of this sort takes into account the populating of the New World as being a continuous series, or waves, of migrations, as opposed to one single movement.

Conclusions

At present, all indications point to the facts that (1) different American Indian varieties exhibit little differentiation, (2) that the sacrum of the American Indian is essentially the same as that of other Mongoloid varieties, (3) that the sacrum of the Mongoloids most closely

resembles that of the Caucasoid varieties, (4) that the greatest dimorphism is to be found between certain Negroid and Caucasoid varieties, and (5) that the sacrum of Paleo-Amerinds, or earliest varieties, will closely resemble that of Paleo-Asiatics and Causoids, whereas that of Ceno-Amerinds, or recent varieties, will be most closely related to the later Asiatics.

Literature Cited

1. Radlauer, Curt. 1908. Beiträge zur Anthropologie des Kreuzbeines. Gegenbaurs Morphologisches Jahrbuch. **38**:321-447.

2 Trotter, Mildred. 1926. The Sacrum and Sex. American Journal of Physical Anthropology. **9**, No. 4:445-450

The Use of Female Crania in Demonstrating Racial Relationships as Exemplified in Two Upper Mississippi Amerind Groups[1]

J. KENNETH SMAIL, Indiana University

Introduction

This study considers three distinct but interrelated problems, which can be set forth as follows:

Problem 1. In previous studies that have dealt with the assessment of the degree of relationship between a number of racial groups of prehistoric American Indians, almost exclusive use has been made of male crania. Because of the practical problem of assembling a statistical sample of skeletal material from widely scattered areas, and, in addition, the very paucity of prehistoric crania which have been excavated under test conditions or are otherwise fully documented, the data from female cranial series cannot afford to be disregarded. It would therefore be of considerable benefit to determine whether female crania, if used, would be as suitable as those of males in determining racial relationships. In this study, two cranial series, each consisting of approximately an equal number of males and females, are examined and compared to determine the degree of similarity in their respective metrical, indicial, and morphological characteristics. Both series have been assigned to the Upper Mississippi Phase, one to the Fisher, or Heally, Focus (Oakwood Mound), and the other to the Anderson Focus (Fort Ancient Aspect).

Problem 2. Given the above archaeological relationships for the Oakwood and Anderson skeletal series, it would also be of value to determine to what extent these two geographically separated groups are physically related. This study attempts to determine the degree of physical similarity that exists between these two series, independently using both male and female crania in making the metrical, indicial, and morphological comparisons. Following this, an effort is made to place the Anderson and Oakwood series into the overall physical, archaeological, and linguistic framework of American Indian racial history as proposed by G. K. Neumann (6; 7).

Problem 3. A third problem, implicit in problems 1 and 2, is primarily methodological. A test is made of the reliability of the specific combination of metric measurements, indices, and morphological observations used to demonstrate the closeness of relationship of skeletal material that has been placed into the same varietal category. This study is also useful in demonstrating the validity of certain varietal groupings that have been assigned previously.

[1] I would like to express my appreciation to Professor G. K. Neumann for his assistance in formulating the problems discussed in this paper and for permission to make use of the skeletal material and related data.

Discussion

It might be asked why past studies have used male crania more or less exclusively. Although much of this male emphasis probably "just happened," and subsequently became "traditionally acceptable," two additional reasons, one anatomical, the other practical, might be given. First, the greater absolute body size of males, which has probably permitted greater allometric growth, has resulted not only in greater relative male variability, but has also made any diversity that does appear between male groups more obvious, both to the eye and the anthropologist's calipers. Second, and closer to the point in this particular study, G. K. Neumann's exclusive use of male crania, in his extensive field work with regard to American Indian racial history, was primarily a result of the great amount of work involved and time consumed in collecting widely dispersed data; quite simply, the addition of female cranial data to research that had already reached major proportions was, for that particular study, literally out of the question.

The Oakwood Mound, near Joliet, Illinois, was excavated in 1928 by a University of Chicago field party, G. K. Neumann being responsible for the collection of the skeletal material. Because of its rather close resemblance to the artifactual material in the uppermost level of the Fisher site (10), the Oakwood Mound Component is considered to be part of the Fisher (or Heally) Focus, of the Upper Mississippi Phase. The Fisher Focus no doubt constitutes a separate, though as yet unnamed, Aspect. W. K. Moorhead himself excavated the Anderson village site and cemetery between 1887 and 1891. Sites of the Anderson Focus are situated along the central valleys of the two Miami rivers in Ohio (5), making the Anderson Focus the most northwesterly of the four foci of the Fort Ancient Aspect, Upper Mississippi Phase. A complete description of Fort Ancient may be found in Griffin (4).

The framework of American Indian racial history as utilized in this study may be briefly summarized as follows. The first well-documented Amerind populations in the eastern United States appear in Archaic times. By ca. 4000 B.C., an ancestral Paleoamerind biological population had differentiated into the Iswanid variety, found predominantly in the river basin areas south of the Ohio valley and represented by the Archaic Indian Knoll series, and the Lenid variety, a more northern Great Lakes area population, exemplified by the several Old Copper-Early Woodland skeletal series. Beginning in Middle Archaic times (2500-1500 B.C.) however, physically larger and more brachycephalic Meta-amerind populations began to appear in a number of areas in the Eastern United States. Thus, by Late Archaic-Early Woodland times, the Iswanids had given rise to the derived Walcolid variety, a group that later came to be associated with the Middle Mississippi cultural manifestation and the Muskogean linguistic family. The Lenids, on the other hand, had differentiated by Middle Woodland (Hopewellian) times into a derived Ilinid variety that is associated with both late Woodland and Upper Missssippi cultures in the areas south of the Great Lakes. Linguistically, these Ilinids are mostly of Central Algonkian stock.

The Walcolid and Lenid-Ilinid varieties were therefore contemporaries in the Middle West through the prehistoric period, from Archaic times onward. However, in Late Archaic-Early Woodland times, the distribution of the early Walcolids increased, as they expanded, probably from the Middle Mississippi area, northward up the Missouri and Mississippi, and east and southward up the Ohio and Tennessee-Cumberland, drainage basins. During this period the Lenid-Ilinid variety was peripheral. By Middle Woodland times, however, with the appearance of the Hopewellian and related cultures in Ohioan, Illinoian, and other centers, renascent Ilinids seem to have replaced the earlier Walcolid "invaders" and again became dominant in the Great Lakes area. After the demise of the Hopewellian culture(s), a second Walcolid northward movement occurred in Early Mississippi times (ca. 1000-1200 A.D.) in the form of the Middle Mississippi culture. By the late prehistoric period, these Middle Mississippi Walcolids dominated the Mississippi, Missouri, and Ohio river valleys where, often in close contact with indigenous Late Woodland Ilinid peoples, the Upper Mississippi culture formed. Many transitional Walcolid-Ilinid and Middle Mississippi-Late Woodland physical and cultural traits are evident, for example, in the Fort Ancient Aspect of southwestern Ohio. The Anderson Focus, considered in this study, is probably the most Ilinid and Woodland-like of the four Fort Ancient foci. In the northeastern plains area, the Dakotid variety, derived from an earlier Cenoamerind Deneid-like population (7:68), came into contact with Walcolid Caddoan-speaking Middle Mississippi peoples advancing up the Missouri River, borrowed freely of their culture and subsequently pushed eastward, coming as a result into considerable contact with Late Woodland Ilinid groups in the Iowa, southwest Wisconsin, and northern Illinois area and here contributing to the formation of what is known archaeologically as the Oneota Aspect. The Fisher Focus (Oakwood Mound) peoples are related in part to this Oneota development.

In dealing with the data obtained from the skeletal series used in this study (ie.-121 male and female crania), the following statistical procedure was employed. Some 38 absolute measurements were taken from various points on the skull, 27 indices then being calculated from these measurements. Of greater genetic value, 46 morphological observations were also made on each skull. Arithmetic means, standard deviations, and their respective standard errors were then computed for each of the measurements and indices. Finally, both male and female series were compared (male with male, female with female) by means of Student's "t" test, and significant differences, if they existed, were determined at the 10%, 5%, and 1% levels of significance. It should be emphasized that in demonstrating racial similarities and dissimilarities, the procedure described above makes use of an entire constellation of measurements, indices, and morphological observations in an attempt (1) to determine which characteristics reflect the common descent of two populations of the same variety, and (2) to determine the direction of variability of the two biological populations. Significant differences in one, a few, or even several of these traits do not therefore necessarily imply varietal differences.

Rather, such differences are only demonstrable when many traits or groups of traits show significant variation. This procedure is thus consistent with G. K. Neumann's view that a variety (race) is a zoological group of a certain order of differentiation (30%-80%) characterized by the possession of a combination of a selected number of inherited morphological attributes that reflect its history. A more detailed treatment of statistical method may be found in Smail (11:19).

The measurements and indices of the Anderson and Oakwood series were paired and compared as follows: Oakwood males with Anderson males; and Oakwood females with Anderson females. At the 10%, 5%, and 1% levels of significance, the results in Table 1 were obtained. At the 5% level, the specific measurements and indices which showed statistically significant differences were as shown in Tables 2a and 2b.

The above tables illustrate two factors concerning this study's use of female crania in determining racial relationships:

1. Comparisons of female skeletal series tend to show more significant differences at all levels (ie.-10%, 5%, and 1%) than comparison of values of male series. This is more obvious with regard to indices (9 females: 3 males at 5% level) than measurements (8 females: 5 male at 5% level).

2. Of the measurements and indices that actually do vary, there is much similarity between the male-male and female-female comparisons. In the total (for both sexes) of eight significantly different measurements, five are identical. As for the indices, two of the three significant differences in the male series find their counterparts in the female series. In addition, as mentioned above, the female series comparisons show several additional significant differences (i.e.-3 measurements and 7 indices) that do not occur in the male series comparisons.

On the basis of this particular study, it would seem that comparisons of female series show greater variability (i.e.—statistically significant differences) than comparisons of male series from the same sites. It is evident that additional research of a similar nature should be undertaken to ascertain whether this would apply to other American Indian populations as well, ar whether in some, male series comparisons vary more than females. In this connection, three precautionary statements might be made concerning the above "male vs. female" problem:

1. First, if it could be shown that, on the whole, comparisons of female series consistently show greater statistical variability than comparisons of male series, or vice versa (i.e.—male series consistently vary more than females), it would probably be best for accuracy's sake to use both male and female series comparisons in problems concerning the assessment of racial and varietal similarities and differences, even though this would undoubtedly involve considerable extra time.

2. Second, if it could be shown that comparisons of male series and comparisons of female series from the same sites show quite similar degrees of statistical variability, then either male or female series comparisons could accurately be used, depending on whether it were

males or females that occurred in the greater number or better condition.

3. Third, and in some respects most important, if further study shows that, in some Amerind racial or varietal groups, the female series consistently shows greater statistical variability than males, while in other groups the male series demonstrates greater variability than females, several problems are raised. For example, in a comparison between hypothetical populations A and B where this situation might occur, should the investigator chance comparing males that show more variability than females in population A with males that are less variable than females in population B, or vice versa? In this case, the only way that the investigator could compare hypothetical populations A and B would be to compare the males of one group with the females of the other. This of course raises even more problems. Absolute metrical comparisons would be essentially useless, while indicial comparisons could well be difficult to correlate effectively. In addition, the morphological traits selected would have to show a relative absence of linkage with sex. These problems are certainly worthy of further experimental verification.

As has already been pointed out, the measurements and indices in this study that do show significant differences in the male and female series comparisons are to a considerable extent the same measurements (i.e.—B, DS, SMN, MB, LOBD) and indices (SMN/MN, MB/ML). In other words, both males and females of the Oakwood and Anderson series are different in similar respects, the only exception being the aforementioned greater overall variability of the females. It is evident, however, that in the final analysis, taking into consideration all metric and morphologic factors, that differences that are not significant far outweigh those that are. The two populations under consideration here, Oakwood and Anderson, in actuality show a high degree of overall similarity.

Still further, there is a strong suggestion that the indices that do show significant differences, especially with regard to the Oakwood female-Anderson female comparisons, are mostly concerned with the general breadth of the skull (and face). For example, seven of the nine significantly different indices are computed by using the measurements B (maximum breadth), TFB (total facial breadth), and IOB (interorbital breadth). These differences do not appear to any significant extent in the male series comparison. Two reasons might be suggested for this:

1. Statistical sampling error—possibly an accidentally biased sample, which in this case, at the 5% level of significance, could occur one time in twenty.

2. Exogamy—Oakwood broad-skulled females could have been brought into the tribal group from some outside broader-skulled population (see below).

How then may the Oakwood and Anderson materials be fitted into the physical, archaeological, and linguistic framework proposed by G. K. Neumann (6:7)?

1. A comparison of the physical variability, with the exception of tendency toward skull broadness and somewhat greater variability in the Oakwood females, shows the two groups to be highly similar, if not virtually identical. Both the Oakwood and Anderson groups fit metrically, indicially, and morphologically into the Ilinid physical variety.

2. As can be demonstrated from several archaeological studies (4;10) of the Oakwood and Anderson sites, both assemblages may be placed in the Upper Mississippi Phase, the Anderson Focus in the Fort Ancient Aspect and the Fisher Focus (Oakwood) "near" to the Oneota Aspect.

3. From a historical standpoint, the probability is quite high that both groups are of the Central Algonkian linguistic family. The Oakwood Cemetery group has previously been identified with the historic Miami tribe, who were known to have been in the northern Illinois area during the late prehistoric period (9:50). The Anderson Focus group has been equated with the historic Shawnee (3;4;12), a tribal group that centered in the Ohio Valley at this time. Since both the historic Miami and Shawnee spoke Algonkian languages, it seems quite likely that their late prehistoric forbears did also.

Demographic Considerations

From the above data, it may be surmised that the Anderson and Oakwood populations, though geographically separated by some 300 miles, were similar physically, culturally, and linguistically. Physically, both populations were Ilinids. Archaeologically, both populations were Late Woodland groups on the peripheries of the Walcolid Middle Mississippi expansion up the Ohio, Missouri, and Mississippi rivers. Even though, as shown by the archaeological record, each absorbed a considerable number of Middle Mississippi culture traits, much of it no doubt by diffusion, neither shows much physical admixture from groups of the Walcolid varety. The Anderson Focus population, in G. K. Neumann's estimation, represents a relatively inbred Ilinid stock, an observation that is especially interesting in view of the fact that the other foci of the Fort Ancient Aspect (ie.—Feurt, Baum, and Madisonville) have been classified as predominantly Walcolid (8). The location of the Anderson Focus on the northwest periphery of the Fort Ancient Aspect, where it is known that Late Woodland Ilinid groups can also be found, perhaps explains this. The Oakwood skeletal series, like that of the Anderson Focus, also indicates a preponderance of Ilinid physical characteristics. Archaeologically, this seems compatible with Caldwell's (2:37) view that sites of the Upper Mississippi Phase (including those of the Fisher Focus) show mixture with older indigenous culture elements. Since these indigenous culture elements are of unquestionable Woodland affiliations, it can be seen that the Oakwood population fits quite well into G. K. Neumann's Woodland-Ilinid equation.

The somewhat greater broadness of skull (and perhaps face) indicated in the Oakwood Ilinid population, especially obvious in the fe-

males, would seem to be evidence of what may be termed a Dakotid influx or admixture, emanating probably from the north central plains. This would seem consistent with the known physical and cultural facts. According to G. K. Neumann (7:68), it is evident that the Oneota culture complex, to which the Oakwood material is related, owes much of its Upper Mississippi flavor to the fact that it was introduced by Chiwere-speaking Siouan groups. These Siouan populations have previously been identified as at least partially of the Dakotid variety (6).

Another possibility for the seeming appearance of Dakotid traits in the Oakwood population revolves around the known fact that the Indians of the "woodland" area adjacent to the great plains made yearly forays into the grasslands to hunt bison. It is quite likely that in the course of their travels, the Miami, Iliwinek, and other woodland hunters often came into not so friendly contact with plains Dakotid groups, and when victorious, brought back both Dakotid women and children. According to Bauxar (1:45), the Iliwinek, and undoubtedly others, "took wives and captives from all the surrounding tribes and from Chiwere, Dakota, and Dhegiha Sioux to the north, west, and south. Their bravest feat was to steal live captives from their enemies. Male captives taken in raids or warfare were put to death, while children and marriageable women were kept as 'slaves', the former growing up as members of the tribe and the latter generally becoming concubines of their captors".

It can thus be hypothesized that the greater broadness of skull (and face) indicated in the Oakwood females, and, to a smaller extent the Oakwood males, has, tentatively at least, both a genetic and historical explanation. It is interesting to observe in this respect that had only male crania been used, this rather significant relationship would probably not have appeared. In addition, the generally greater statistical variability of the Oakwood female-Anderson female comparisons can perhaps also be explained on the basis of the above-mentioned Dakotid admixture. In other words, both Oakwood and Anderson males were quite Ilinid, and thus varied little in comparison with each other, whereas the degree of variability between the unmixed Anderson females and the mixed Ilinid-Dakotid Oakwood women was relatively greater.

Conclusions

Problem 1. On the basis of a metric and morphologic comparison of the Oakwood and Anderson cranial series, it is evident that data from female cranial series, heretofore used rather sparingly in studies of prehistoric midwestern Amerind populations, should be taken into consideration whenever possible. The essential identity that is indicated between these two series when male crania are used is closely corroborated by comparisons of the females.

Problem 2. Comparison of the cranial data from the Oakwood and Anderson sites, independently comparing Oakwood males with Anderson males, and Oakwood females with Anderson females, reveals a high degree of physical similarity, or virtual identity, between these late

prehistoric populations. The possibility is suggested that a tendency toward broadness of skull (and face) in the Oakwood females is explainable by admixture with the Dakotid physical variety from the great plains.

Problem 3. The reliability of the specific combination of metric measurements, indices, and morphologic observations used in this study is amply demonstrated by the fact that independent comparisons of male and female series from the Oakwood and Anderson sites give virtually identical results. In addition, this high degree of similarity between the results of the male and female series comparisons further validates the Ilinid physical variety as originally defined.

TABLE 1

	Total Significant Differences at —% Significance Level		
	10%	5%	1%
Measurements: (total 38)			
Oak. male vs. And. male	9	5	4
Oak. female vs. And. female	13	8	4
Indices: (total 27)			
Oak. male vs. And. male	6	3	3
Oak. female vs. And. female	11	9	6

TABLE 2a

Measurements Significant at 5% Level

Oak. male vs. And. male	Oak. female vs. And. female	Explanation of Symbols
B	B	Maximum breadth
DS	DS	Dacryal subtense
SMN	SMN	Subtense minimum nasal breadth
MB	MB	Maxillo-alveolar breadth
LOBD	LOBD	Left orbital breadth
	UFH	Upper facial height
	SIOB	Subtense interorbital breadth
	RL	Minimum ramus breadth

TABLE 2b

Indices Significant at 5% Level

Oak. male vs. And. male	Oak. female vs. And. female	Explanation of Symbols
DS/DC		Nasal root height
SMN/MN	SMN/MN	Nasal bone height
MB/ML	MB/ML	Maxillo-alveolar
	B/L	Cranial
	H/B	Breadth-height
	H/(L+B/2)	Mean height
	MF/B	Trans-fronto-parietal
	UFH/TFB	Upper facial
	MF/TFB	Zygo-frontal
	SIOB/IOB	Facial flatness

Literature Cited

1. Bauxar, J. J. 1959. The Historic Period. Illinois Arch. Surv., Bull. No. 1:40-58.
2. Caldwell, J. R. 1959. The Mississippian Period. Illinois Arch. Surv., Bull. No. 1:33-39.
3. Faulkner, C. H. n.d. Prehistoric-Historic Continuities in the Western Great Lakes Area. (unpublished manuscript)
4. Griffin, J. B. 1943. The Fort Ancient Aspect.

5. Morgan, R. G. 1952. Outline of Cultures in the Ohio Region. In J. B. Griffin; Archeology of the Eastern United States, pp. 88-98.

6. Neumann, G. K. 1952. Archaeology and Race in the American Indian. In J. B. Griffin: Archaeology of the Eastern United States, pp. 13-34.

7. ————————, 1960. Origins of the Indians of the Middle Mississippi Area. Proc. Ind. Acad. Sci. **69**:66-68.

8. Neumann, H. W. 1960. Diagnostic Morphological Traits for the Walcolid Variety of American Indians. Proc. Ind. Acad. Sci. **69**:69-72.

9. Omoto, C. E. 1960. Identification of a Prehistoric Indian Skeletal Series from Will County, Illinois. M.A. Thesis, Indiana University.

10. Skinner, R. R. 1953. The Oakwood Mound. An Upper Mississippi Component. Jour. Illinois State Arch. Soc., n.s. 3:no. 1.

11. Smail, J. K. 1965. The Use of Female Crania in Demonstrating Racial Relationships: A Comparison of Two Prehistoric Upper Mississippi American Indian Populations. M.A. Thesis, Indiana University.

12. Temple, W. C. 1958. Indian Villages of the Illinois County, Illinois State Mus. Sci. Pap. 2:pt. 2.

Preliminary Report on the Hopewellian Skeletons from the Klunk Site, Calhoun County, Illinois

King B. Hunter, Indiana University

This paper constitutes a preliminary assessment of a study of about three hundred skeletons from the lower Illinois River valley that were excavated by Mr. Gregory Perino of the Thomas Gilcrease Foundation of Tulsa, Oklahoma.

In the way of introduction to the Klunk mound group material and its significance for eastern United States prehistory, some background should be given concerning the racial history of the populations associated with the cultural traditions. The broad model proposed by Neumann (5) will be followed here, and is summarized as follows. The most ancient populations in eastern North America which are reasonably well documented appear in early Archaic times, as early as 4000 B. C., and perhaps earlier in a few cases. Two widely distributed and quite homogeneous populations dominate the whole of the eastern United States at this time, both seeming to have considerable antiquity, and showing perhaps, a generalized common ancestor. In the northern area, primarily associated with a Great Lakes area Archaic cultural pattern, is the Lenid variety, described elsewhere by Neumann (6). An example is Old Copper. The area south of the Ohio Valley is populated by groups which may easily be distinguished from the Lenids, and which are generally associated with the southern riverine Shell Mound Archaic cultural pattern. These populations are consistently of the Iswanid variety, described by Neumann. The largest sample of this variety to date comes from Indian Knoll, which has a radiocarbon date of 3352 B. C. ±300 years (1). The earliest material from Modoc Rock Shelter is also Iswanid.

Neumann proposes a differentiation from Lenid to the Ilinid variety, and from Iswanid to the Walcolid variety, beginning in Medial Archaic times, perhaps as early as 2500 B. C. or earlier. An Illinid population is associated with Glacial Kame. This process of Lenid to Ilinid differentiation may also be observed in Classic Hopewell times, according to Neumann. The sequence of Modoc Rock Shelter reflects the progressive differentiation from Iswanid to Walcolid. The Walcolid variety, especially, is quite widespread by Terminal Archaic, and Early Woodland times, with the Iswanid becoming marginal or peripheral by Early Woodland times.

During Terminal Archaic and Early Woodland times the Walcolids apparently enjoyed a considerable extension of their range, moving up the Ohio Valley into the New York and eastern Great Lakes area, and into the Illinois Valley. In the Illinois Valley they are associated with Red Ocher and Morton, and in the Northeast, with Laurentian and

Point Peninsula. It has also been suggested that a population of the Walcolid variety was associated with Adena in the Ohio Valley. In general, the Lenids and Ilinids appear to be peripheral to the distribution of these groups during this time. With the appearance of Hopewell in Middle Woodland times, however, the Lenids once again become the dominant population north of the Ohio River and in the Illinois Valley (2). The Middle Woodland population in the Southeast is predominantly Walcolid, associated with such cultures as Copena and Marksville, while the differentiated Ilinid populations become dominant in the north. A final northern expansion of the Walcolid population during the Hopewell breakdown in Late Woodland times takes place in connection with the spread of Middle Mississippi culture. In most of the cases discussed above, little admixture is indicated, with the possible exception of Adena, in which case there may be a certain amount of Walcolid-Ilinid admixture. As a consequence, the populations associated with these culture complexes ought to be reasonably homogeneous.

The material from the Klunk mound group is rather significant when considered in this framework, in that it offers evidence which may be used to test certain of the foregoing hypotheses. The site may be briefly described as follows. The mounds are located on the western bluff overlooking the Illinois River, in Calhoun County. Archaeological evidence in the form of log tombs, subfloor burial pits, zoned Hopewell pottery, Hopewell Stamped rocker-dentate pottery, and so on, indicates that the main body of the material is Classic Illinois Hopewell. The burials associated with this culture pattern constitute the largest sample of the Illinois Hopewellian population extant. One Hopewellian mound overlies a low Archaic or Early Woodland mound, which may have Red Ocher affiliations. This material offers an interesting comparison to the Hopewell series, and to Early Woodland populations from other sites. Finally, a few intrusive Jersey bluff burials are found in the mounds.

A preliminary investigation of the population associated with Classic Hopewell at the Klunk site results in an interesting and significant statistical patter. Viewed in a cursory manner, it tends to exhibit a rather sigificant amount of variability, although it is primarily Lenid in character. Closer scrutiny of the material reveals a very consistent direction in the skewness of the statistical description—that is to say, the variability is not at all random. Those characteristics which diverge from the expected Lenid pattern, if considered as a group, are just those characteristics and tendencies which differentiate the Lenid from the Ilinid, in greater or lesser degrees.

Furthermore, there is no indication of any tendencies toward Walcolid characteristics, ruling out the possibility of significant admixture from this population. This is entirely consistent with Neumann's proposal that Classic Hopewell is a period of Lenid to Ilinid differentiation.

It is interesting to note further that those burials which are associated with Bluff culture are consistently Ilinid, and compare very nicely with the material from the Schild site. This last is under preparation

in the same laboratory, and promises to be a large and very homogeneous sample of the Jersey Bluff population.

The Archaic Early Woodland material which has been examined and given a radiocarbon date of 908 B. C. comprises a small but very homogeneous sample that is unquestionably Walcolid. This material is tentatively classified as Red Ocher. This is not particularly surprising since it is during this period that a differentiation of Iswanid to Walcolid is hypothesized. Consequently, some Red Ocher groups would already be expected to be clearly Iswanid, some clearly Walcolid, and some in an intermediate condition between the two.

Conclusions

1. The hypothesis that the Illinois Hopewell population is essentially Lenid is strengthened by a preliminary investigation of the Hopewellian skeletal material from the Klunk Mound group.

2. The proposed Lenid to Ilinid differentiation during Classic Hopewell times is also reflected in this investigation.

3. The Lenid population associated with this Illinois Hopewell group appears to be essentially identical to the population associated with Ohio Hopewell, which is contemporaneous.

4. An examination of the presumed Red Ocher burials indicates a definite Walcolid association, which is expected.

5. The few Jersey Bluff burials present are consistently Ilinid, and compare very well to other Bluff populations examined.

6. A northern source for certain of the characteristics that influence the development of Hopewell out of the indigenous Adena and Red Ocher is indicated by the appearance of certain Point Peninsula ceramic characteristics, such as dentate stamping. This helps to explain the appearance of Lenids in Hopewell, since their distribution at this time was to the north and west of the Illinois and Ohio Valleys. This is pointed out by Griffin (3 and 4).

Literature Cited

1. Deuel, Thorne. 1958. American Indian Ways of Life. Springfield: Illinois State Museum.
2. ————————, editor. 1952. Hopewellian Communities in Illinois. Springfield: Illinois State Museum.
3. Griffin, James B. 1952. Culture Periods in Eastern United States Archaeology. In: Archaeology of Eastern United States. J. B. Griffin, ed., pp. 352-64. Chicago: Univ. Chicago Press.
4. ————————, 1958. The Chronological Position of the Hopewellian Culture in Eastern U. S. Anthro. Papers Museum of Anthro., Univ. of Michigan No. 12 Ann Arbor; Univ. of Michigan.
5. Neumann, Georg K. 1952. Archaeology and Race in the American Indian. In: Archaeology of Eastern United States. J. B. Griffin, ed., pp. 13-34. Chicago: Univ. Chicago Press.
6. ————————. 1960. Origins of the Indians of the Middle Mississippi Area. Proceedings of the Indiana Academy of Science **60**:66-68.

Comparison of Osteoarthritis in Three Aboriginal Populations

FLORENCE HANTSCHKE CHAPMAN, Indiana University

Three groups from geographically different environments have been studied for incidence and degree of osteoarthritis. One of them, the Modoc Rock Shelter people, an early Midwestern group (3325-2765 B.C.), was reported on last year (3). There were 26 skeltons used from that group. The data has been compared with that obtained from 54 Pre-Aleuts excavated by Ales Hrdlicka (9) on Umnak Island near the Harbor of Nikolski.[1] This group (3018 ± 230 years ago, (10)) formed a breeding isolate because of the geography and foggy climate of the Aleutian Islands. The other material was from Point Barrow, Alaska and is known as the "Old Igloo" series (6, 12) and represents the Birnirk culture (5, 11), now dated as 531-815 A.D.

32 of these strange brown skeletons were suitable for this study. Animal skin coverings and freezing conditions caused a state of preservation approaching mummification. There was no mineralization and little bone decay but the bones are very brittle. The uniform cranial measurements indicate that this group also is outside the range of local variation. Hrdlicka considered it to have been a recent immigrant group (8) to the Pt. Barrow area.

One of the most interesting observations about the Modoc group was that four of the five teenagers showed signs of beginning osteoarthritis, a slight bony "lipping" on the anterior bodies of the vertebrae. In the Pre-Aleuts only one female of the four "teens" showed similar signs which were uniform throughout the cervical, thoracic and lumbar regions. In contrast, the Point Barrow people, with one exception did not have the disease until the fourth decade. It was then present to the same degree (Stages II and III) as in the other groups, showing an increasing osteophytic deposition eventually resembling a mushroom-like eversion. Photographs of advanced stages may be seen on page 61 of the 1962 Proceedings (2). Two females in the 41-50 year range showed a lesser degree of involvement; the men of this age spread did not have as advanced cases as did the Pre-Aleuts in the damper climate.

One Pre-Aleut male in the 20-30 age range had no signs of vertebral lipping but showed a sharpening edge along the articular facets of the joints of the long bones. This appears to be quite common in material studied by the author, including Mexican Indian remains. It reflects the wear and tear of action and weight bearing and shows the beginning of the degenerative process often before it appears in the anterior portion of the vertebral bodies. After the age of 30, all the subjects were

[1]This material is housd in the U. S. National Museum, Washington, D. C. The friendly assistance of Drs. T. Dale Stewart, J. Lawrence Angel, Lucile E. Hoyme and Don Ortner is gratefully acknowledged.

arthritic, although not all in sufficient degree to have caused painful symptoms.

In all groups however the older males showed more advanced stages than the females of the same age. This appears to be characteristic as does the finding that, past 41 years of age, 100% of the subjects show different stages of the malady. In the Modocs and Pre-Aleuts this was true in the 31-40 age range.

A tabulation was made of the type of antero-posterior distribution of osteoarthritis in the vertebral columns of the Pre-Aleut group in cases where sufficient vertebrae were present in each area for purposes of comparison. The ages were arranged as young adult (20-30), adult (31-50) and senile (50+). The Pre-Aleut group showed that a more even involvement from cervical to lumbar vertebrae was four times more common than a more progressive type which jumped two or more stages between cervical, thoracic and lumbar vertebrae. Perhaps the Pre-Aleut way of life caused a more general use of the various regions of the body.

The contrast in diet of the northern groups and the Plains Indians is also considerable. Since the inhabitants of the Arctic Coastal Plain and the Aleutian Islands depended so heavily on the sea, their diet was unusually high in fat and protein and low in carbohydrate except during the long winters when it was possible to approach the starvation point.

Geographic location and climatic conditions appear to have little effect on incidence of osteoarthritis but may be factors in the extent of involvement for individuals (4). It has been shown by Hollander's (7) recent experiment that the physical factors of the environment have a definite and measurable effect on the symptoms of an arthritic. A drop in pressure plus a rise in humidity caused an exacerbation of symptoms in seven of the eight rheumatoid patients and in three of the four osteoarthritics.

A report has just been published (1) on the influence of genetic and environmental factors on the occurrence of rheumatoid arthritis in the Blackfoot Indians of northern Montana and the Pima of southern Arizona. It did not yield statistically significant results however. Apparently, genetic and dietary differences need to be studied more thoroughly.

Literature Cited

1. Bunim, Joseph J., Burch, Thomas A., O'Brien, William M., Sept. 1964 Influence of Genetic and Environmental Factors on the Occurrence of Rheumatoid Arthritis and Rheumatoid Factor in American Indians. Bulletin on Rheumatic Diseases, New York, pp. 349-350.
2. Chapman, Florence Hantschke, 1962. Incidence of Arthritis in a Prehistoric Middle Mississippian Indian Population. Proceedings of the Indiana Academy of Science 72.
3. ..... 1963. The Incidence and Age Distribution of Osteoarthritis in an Archaic American Indian Population. Proceedings of the Indiana Academy of Science 73.
4. ..... Dec. 1963. The Incidence and Age Distribution of Osteoarthritis in a Number of Prehistoric American Indian Populations. Unpublished M.A. thesis, Indiana University, 99 pp.

5. Collins, Henry B., Jr., 1943. Eskimo Archaeology and its Bearing on the Problem of Man's Antiquity in America. Proceedings of the American Philosophical Society, vol 86,2.

6. Ford, James A., 1959. Eskimo Prehistory in the Vicinity of Point Barrow, Alaska. The American Museum of Natural History, p. 14, 17-24.

7. Hollander, Joseph Lee, April 1963. Environment and Musculoskeletal Diseases. Archives of Environmental Health, 6:527-536.

8. Hrdlicka, Ales, 1928-9. Anthropological Survey in Alaska. (Strange Group of Eskimo near Point Barrow), in Bureau of American Ethnology, 46th annual report, Smithsonian Institution, Washington, D. C., pp. 318-329.

9. .....1945. The Aleutian and Commander Islands and Their Inhabitants, pub. The Wistar Institute of Anatomy and Biology, Philadelphia, 624 pp.

10. Libby, Willard F., 1952. Radiocarbon Dating, University of Chicago Press, p. 89.

11. Neumann, Georg K., 1952. Archaeology and Race in the American Indian. Archaeology of Eastern United States, University of Chicago Press, pp. 13-34.

12. Stewart, T. Dale, 1959. Skeletal Remains from the Vicinity of Point Barrow, Alaska, in appendix of Eskimo Prehistory by James A. Ford. American Museum of Natural History, N. Y.

A Preliminary Study in the Paleopathology of an Archaic American Indian Population

Holm Wolfram Neumann, Indiana University

To the present day, relatively little effort has been devoted to the study of paleopathology and application of such a study toward the solving of clinical problems confronting us today. Such a study of dried osseous remains is rather unique in that rarely are significant numbers of such specimens encountered in everyday clinical practice. Then too, many limitations are encountered in studying the pathology of prehistoric human populations. Demineralized bone preparations for microscopic examination, for example, are of little use in such a study since the dried bone specimens are largely mineral in composition and perishable nonmineralized tissue is absent. Diagnosis when possible must be made upon the gross appearance of the pathological bone specimen and often lesions encountered can only be given a descriptive diagnosis and not one of a specific disease since in a number of cases two or more disease vectors may produce indistinguishable results or lesions. Often too, the osseous remains of an individual skeleton may be quite fragmentary due to poor preservation in the soil, poor archaeological excavation techniques or poor treatment and preservation after excavation. These factors also represent further limitations to the study of such specimens.

In examining prehistoric human skeletal remains, one cannot help but notice the relatively high incidence of pathology present. It is this fact which after having attracted the author's curiosity, has led to the detailed, systematic analysis of the pathological bone remains of a prehistoric American Indian population. Necessarily, the material utilized in this study was excavated under carefully followed test conditions. It can be readily noted also that such a study is interdisciplinary in scope, spanning both the medical sciences and the field of anthropology.

The majority of the skeletal remains to be examined are of determinable antiquity, sex, racial and cultural affiliation. One can also roughly determine the approximate age at time of death, certain pertinent ecological factors, subsistence pattern and economy. In this brief survey an examination through the study of dried pathological bone specimens, of the incidence, sex and age distribution, etiology, history or antiquity and pathogenesis of some of the diseases affecting the skeletons of this prehistoric population has been attempted. It is hoped that this brief study will serve as the beginning of such a study on a larger, more comprehensive scale, dealing with populations which lived under differing climates, subsistence and cultural patterns, and dietary intakes; as well as exhibiting racial and constitutional differences and that comparisons and important correlations can be made with present

day clinical data. Information concerning the role which heredity and race play in association with certain pathological conditions may be sought in such a study also since the majority of the populations to be studied are composed of relatively small, inbreeding, homogeneous groups.

As an example, a brief summarized description of one of the skeletons studied for bone pathology follows:

Five different (but not necessarily unassociated) pathological entities are to be found in this unfortunate seventy year old male of the Iswanid physical variety. His skeletal remains came from the Modoc Rock Shelter area in Randolph County, Illinois and date back to approximately 6200 B.C. (Medial Archaic period).

First to be noted is the fact that a development anomaly is present in the sternum. Sternebra number four is perforate since the bilateral centers of ossification failed to fuse in the midline. It may also be noted that a fusion of the manubrium to the body of the sternum has occurred. These anomalies were clinically insignificant as they probably showed no serious clinical manifestations.

More obvious to the eye is the fact that this individual had a complete fusion or ankylosis of the spine (rheumatoid spondylitis) from the fourth thoracic to the fifth lumbar vertebra. A very pronounced degree of kyphosis had resulted. To add to this patient's discomfort (and possibly the cause of his death) a fulminant acute osteomyelitis was present which involved the distal 60-70% of both femora. These bones both exhibited a pronounced degree of bone necrosis, sequestration, and evidence of the formation of involucra and draining sinus tracts.

Finally, the entire skeleton exhibited a very pronounced degree of disuse osteoporosis and in some regions the cortex or dense bone of the skeleton had been reduced to a thickness of less than one millimeter. Of a comparatively minor significance is the fact that this individual also exhibited a moderate degree of osteoarthritis.

Among the general conclusions which can be drawn from this study are the following:

1. Numerous diseases affecting bone which occur in modern times have early archaeological counterparts.

2. The disease showing the highest incidence in this population was, as could well be expected, osteoarthritis. For this reason, a more detailed, comprehensive study of this disease was undertaken.

3. Mechanical stress is strongly indicated as the *major* factor by which joint function contributes to the development of osteoarthritis. This fact was readily demonstratable in a number of the specimens examined. The alteration of normal joint stress due secondarily to infections, endocrinological disease and traumatic fractures are especially to be noted.

4. The relative incidence of the disease encountered in this population or series is greatly influenced by subsistence pattern, ecology, and cultural factors.

Literature Cited

1. Neumann, Georg K. 1952. Archaeology and Race in the American Indian. Yearbook of Physical Anthropology 8:213-255.
2. Fowler, Melvin L. 1959. Summary Report of Modoc Rock Shelter. 1952, 1953, 1955, 1956. Illinois State Museum.

The Early Woodland Manifestation in Greene County, Indiana

Georg K. Neumann and Curtis H. Tomak, Indiana University

In the archaeology of the eastern United States the transitional period from a hunting and gathering to a food producing economy—Terminal Archaic to Early Woodland—is not as well known as a number of earlier cultural manifestations on an Archaic level. Of the latter, culture content, the way of life, and even biological populations themselves have been described in considerable detail, although far less is known concerning broader traditions, particular streams of diffusion, and cultural continuities. This applies equally to comparative work on the biological populations themselves: their origins, population size, migrations, micro-evolutionary differentiation, contacts and mixtures, as well as their eventual fate.

If this is true of the levels of culture, such as the Archaic, or of particular cultures themselves, such as the Great Lakes or Tennessee-Cumberland Archaic, it applies to a still greater extent to the transitional periods between culture climaxes. Often the validity of particular Archaic groupings have been questioned, chiefly because they rested on lithic complexes which may exhibit only limited local specialization. If food production and the use of pottery are added to various local manifestations and adapted to local conditions, it is generally difficult to distinguish the warp and woof that contribute to the cultural whole. Similarly, it is obvious that the early biological populations of the area, although derived from a common gene pool, because of their small size, relative isolation, and wide dispersal, may vary tremendously. All this adds to the difficulty of reconstructing the early history of the different ethnic groups that inhabited the eastern part of the continent. Answers to questions, such as a single or multiple origin of food production or pottery-making, the diffusion of tool traditions or ceremonial complexes, or the question of local physical differentiation versus the advent of a new group to an area, can only be found after detailed interdisciplinary data has been collected under test conditions and analyzed in its total temporal, spatial, and structural setting.

With the aim of contributing to an elucidation of the history of the Middle West in the transition from Terminal Archaic to Early Woodland manifestations, the artifacts from the two sites in Green County that yielded Marion Thick ware are described and compared to Baumer, Fayette Thick, (7) and Red Ocher (4) ceramic types of the same general time level. Lithic artifacts from these two sites are in turn compared with those which were associated with early pottery types of the other areas to determine to what extent these complexes shared traits, and in which particulars they differed.

The present paper constitutes part of an archaeological survey the junior author has conducted along the west fork of the White River

over a period of more than two years, visiting many of the sites repeatedly. This stream, which courses southwest through the central part of Greene County, is joined by Eel River near the town of Worthington a few miles south of the Owen County line. In pre-historic times the interior of Greene County had rather extensive marshlands. These were known as the Worthington Marsh, Four Mile Marsh, Bee Hunter Marsh, and the Goose Pond. The Early Woodland pottery from the Oliver site, which Helmen (9, 10, 11) named Marion Thick, is found in the same drainage approximately eighty miles upstream.

Greene county was originally surveyed for archaeological sites in 1932 by Glenn A. Black (1), who located 32 village sites, 78 camp sites, 2 workshops, one shell mound, eight cemeteries, and 129 artificial mounds. Although Black collected 630 potsherds on the surface and 2,768 from the excavation of two village sites, he reported no evidence of Early or early Middle Woodland pottery. After visiting fifty-seven of the surveyed habitation sites, examining many of the collections in the same area, and locating sixty-nine additional habitation sites, from which 597 potsherds were collected, the junior author found only two sites which produced thick Woodland pottery. The Thompson Site yielded twenty-one potsherds of which thirteen were of this type, and the Davis Site one out of the four found.

The Thompson Site is located upon a projection of high ground which borders the north edge of a former marsh known locally as the Goose Pond. The soil is clay, and the site covers approxmately two acres, being elevated ten feet above the marsh into which it gradually slopes. It is located in the N.E. ¼ of the N.W. ¼ of the S.E. ¼ of Section 28, T.7N., R.7W., of Stockton Township.

Evidence of human burials from the southern end of the site consisted of six skull fragments from at least two individuals whose graves were disturbed during the cultivation of the field. Besides some deer teeth and mussel shells, the evidence for occupation includes the following lithic materials: fire cracked stones, hammer stones, pitted stones, flint spawls, 2 full-grooved granite axes, 2 granite celts, 1 thumbnail scraper, 1 pointed humpbacked scraper, 1 end scraper, 1 expanded base drill, 1 "T"-shaped drill, 9 small side notched projectile points, 1 small side notched serrated point, 1 diagonal notched point, 3 lanceolate points, 1 small triangular point, 2 small bifurcated base points, 6 stemmed points, 5 stemmed barbed points, 3 stemmed weak shouldered points, 1 small tanged weak shouldered point, 1 tanged point, 1 small trianguloid knife, 1 broad deep basal notched point, 8 sherds of grit and sand tempered cord marked pottery, and 13 sherds of coarse grit and clay, thick, plain and cord marked pottery.

The Davis Site is found in the N.W. ¼ of the S.W. ¼ of the S.W. ¼ of Section 4, T.7N., R.6W., of Grant Township. It is located twenty-five feet above the Latta's Creek Bottoms upon a southern projection of a ridge which borders the flood plain of the creek to the south. The soil is sandy, and the ridge slopes rather abruptly into the creek bottoms. The site roughly covers an area 600 feet east and west by 300 feet north and south.

As on the Thompson Site, human skull fragments, deer bone, and mussle shells were found on the surface. Lithic material includes fire cracked stones, hammer stones, pitted stones, flint chips, 1 stemmed scraper, 1 end scraper, 1 "T"-shaped drill, 3 stemmed projectile points, 3 stemmed barbed points, 2 side notched points, 1 bifurcated base point, 2 sherds of sand tempered cord marked pottery, and 1 sherd of thick,

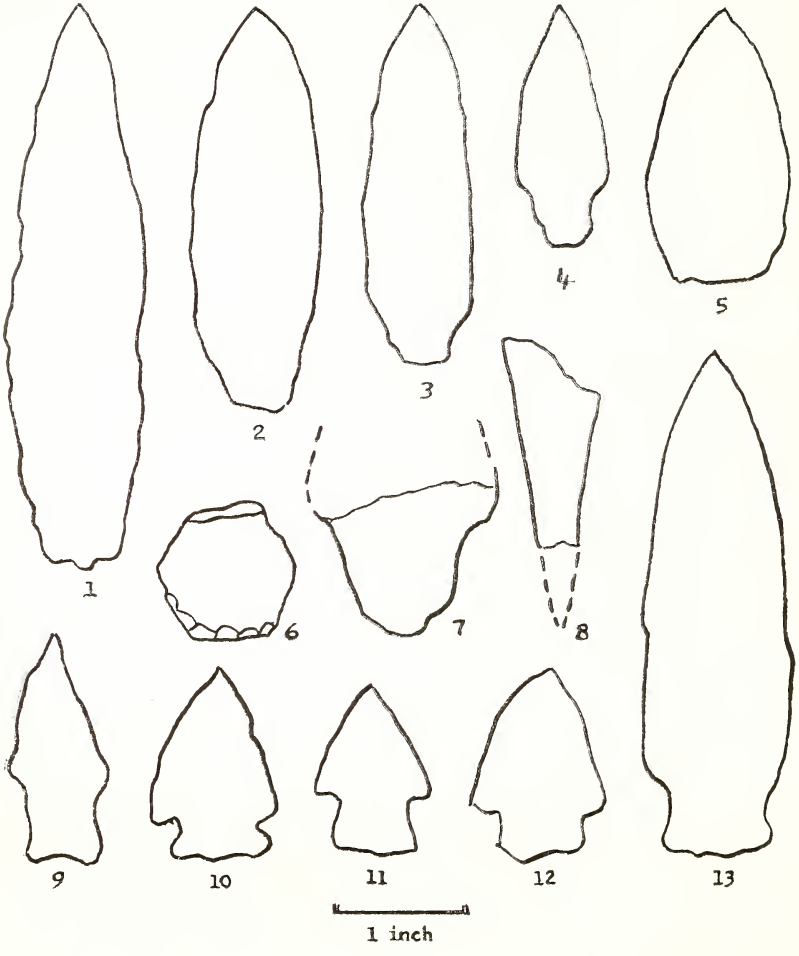


Figure 1

Artifact forms from the Thompson site resembling Baumer lithic material

coarse grit and clay tempered, cord marked pottery. Black reports 1 drill, 2 side notched projectile points, 1 triangular point, 1 knife, and 12 sherds of sand tempered cord marked pottery.

The one Early or early Middle Woodland potsherd found on the Davis Site is very similar to one of the sherds found on the Thompson Site. They are both on the average 15 mm. thick, exhibit cord markings on the exterior, irregular cord wrapped paddle edge markings on the interior, coarse grit and clay tempered, buff colored and quite hard. Besides the similarity of pottery and burials in the living area, the similarity of Woodland artifacts attests to the fact that they represent components of the same focus. These are stemmed barbed projectile points (No. 11 Fig. 1 and No. 4 Fig. 2), stemmed weak shouldered points No. 13 Fig. 1 and No. 1 Fig. 2), small stemmed points (No. 9, 12 Fig. 1 and No. 2, 7 Fig. 2).

The Greene County Thick pottery type has the following characteristics.

Method of Manufacture	coiled (?)
Temper	coarse grit and clay, particles up to 4 mm. in diameter; sand, limestone, and water-worn pebbles occur.
Thickness	walls 7-16 mm., most often 11 mm.; rim 6 mm. (?)
Texture	coarse
Hardness	3.5
Color	tan to buff to orange buff to reddish buff to gray; core buff and/or dark gray
Lip	flat to very slightly rounded (?)
Rim	straight to slightly flaring (?), vertical cord markings to lip (?)
Body	exterior usually cord marked (sometimes smoothed), sometimes plain; interior usually plain with irregular cord wrapped paddle edge impressions occurring
Base	unknown
Decoration	1 plain body sherd shows 2 parallel lines 4 mm. wide and spaced 18 mm. apart produced by a cord wrapped dowel or paddle edge.

Because of general resemblance and association with early Woodland lithic material, logically the thick Woodland pottery from the Thompson and Davis sites, should be compared with similar early types of neighboring areas. These include Fayette Thick pottery found in Fayette County, Kentucky, Red Ocher Crushed Rock pottery found in Fulton County, Illinois, Baumer Plain and Fabric Marked pottery found in Massac County (3), Illinois, and Marion Thick pottery from Marion County, Indiana. Similar types are known from Owen, Marshall, and Vigo Counties, Indiana.

In a comparison with Fayette Thick it was found that the Greene County Thick is generally thinner and harder. The texture of both are coarse. Fayette Thick shows an absence of clay tempering, and gray

coloring. The rims of both types are cord marked but the markings of Green County Thick are vertical whereas those of Fayette Thick are horizontal or oblique. Both have plain or cord marked exteriors, but Fayette Thick is often cord marked or fabric impressed interiorly in contrast to Greene County pottery. Fayette Thick often shows a pinched over cord-marked exterior, whereas the exterior markings on Greene County sherds is often smoothed and shows a parallel line design on one plain sherd.

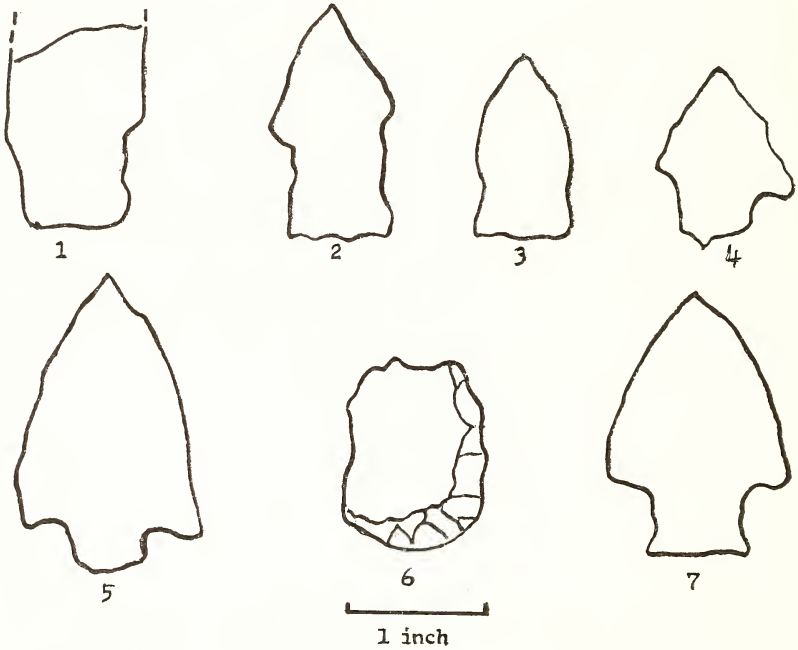


Figure 2

Artifacts from the Davis site resembling Baumer lithic material

As in the Fayette Thick type from Kentucky, the Red Ocher Crushed Rock type from the Illinois Valley shows no clay tempering and the vessels are generally thicker than those from Greene County. Further, it does not show the color range of the Greene County pottery, nor does it exhibit the smooth exteriors or interiors. But all three types are of approximately the same thickness, texture, and color range. The Green County pottery is quite harder than either of the other two. All exhibit flattened lips and similar rim construction, with Baumer sometimes showing insloping rims. Coarse grit and waterworn pebble tempering material is characteristic of all three with the size of the particles generally larger in Marion Thick. Limestone, clay, and sand tempering occur in the Baumer and Greene County pottery, whereas

it is absent in Marion Thick. Marion Thick and Greene County vessels are usually cord-marked on the exterior with the markings smoothed in some instances; Baumer is usually fabric impressed on the exterior with occasional cord markings which are sometimes smoothed. Marion Thick is rarely fabric impressed and lacks plain exteriors, which are sometimes found on Greene County and Baumer sherds. The interior of Greene County and Baumer sherds are usually plain, whereas that of Marion Thick is usually cord-marked or fabric impressed, although some plain interiors do exist. None show the cord wrapped paddle edge impressions of the Green County type. The Marion Thick pottery which has been described is entirely undecordated; Baumer pottery exhibits punctate and incised designs on the plain variety only, whereas one plain sherd from the Thompson site shows parallel cord wrapped paddle edge or dowel produced lines on the exterior.

The Greene County Thick pottery seems to be more closely associated with Baumer pottery than with Marion Thick pottery in terms of tempering material, especially in regards to the increased particle size and the absence of clay and sand in the Marion Thick type. The fact that Baumer sometimes exhibits insloping rims, as well as the similarity of Marion Thick rims to Green County rims is minimized due to the questionable association of the rim sherds classified as Greene County Thick pottery. The Greene County pottery shows more of an affinity for Baumer than for Marion Thick in terms of interior surface treatment—usually plain as opposed to usually cord marked—but differs from both by the presence of cord wrapped paddle edge impressions. The exterior of Greene County sherds is much more like Marion Thick than Baumer, which is usually fabric impressed in contrast to cord marked. Both Baumer and Greene County pottery show designed exteriors, but they differ in style, whereas no decorated Marion Thick sherds were noted.

According to Griffin (8, p. 98), who briefly touches upon possible interrelationships of the earliest ceramics of the Middle West, the different kinds of pottery should be regarded as various types of the same ware. He specifically includes Marion Thick, Baumer, Crab Orchard Fabric Marked, Fayette Thick, and even Vinette I of the northeastern United States in the same category. We herewith would add Greene County Thick as an additional type of the Early Woodland ware, with possible closer affiliation to Baumer and Marion Thick than to the other types. This may in part be due to greater spatial and temporal separation from the Red Ocher complex and the Fayette type of the Early Adena period. The employment of clay tempering by both the Baumer and Greene County communities is suggestive of contemporaneity and that the idea may have diffused from southern Illinois up the Wabash and White rivers.

Red Ocher Crushed Rock Type (2)

Method of Manufacture	unknown
Temper	coarse crushed rock
Thickness	average 14 mm.
Texture	little preparation of paste

Hardness	2.5
Color	tan or yellow buff
Lip	(?)
Rim	insloping or slightly flaring
Body	exterior basketry impressed (?); interior cord marked (?), cord wrapped paddle edge markings (?)
Base	unknown
Decoration	unknown

Fayette Thick Type (6)

Method of Manufacture	coiled
Temper	coarse grit, limestone and flint predominant
Thickness	10-17 mm., average 14 mm.
Texture	coarse
Hardness	soft
Color	light buff to orange buff
Lip	flattened
Rim	horizontal or oblique cord markings
Body	walls vertical (?); exterior plain or cord marked, cord markings often vertical; interior cord marked, fabric impressed, or plain
Base	flat (?)
Decoration	pinched decoration over cord marked exterior, cylindrical handle riveted to wall sometimes present

Baumer Plain and Fabric Marked Types (12)

Method of Manufacture	coiled
Temper	coarse grit, usually clay and limestone, particles up to 3mm. in diameter, sand and/or waterworn pebbles sometimes present
Thickness	8-15 mm.
Texture	coarse
Hardness	2.0-2.5
Color	dull gray to buff to brown to reddish buff to black
Lip	flattened
Rim	straight, insloping, or slightly flaring
Body	straight sided tapering somewhat to base; exterior usually fabric impressed, some plain, cord marked occurs with some of the markings smoothed; interiors usually plain
Base	small, heavy, and flat; often definite heel at juncture of base and wall
Decoration	punctate and incised on plain variety only

Marion Thick Type (9)

Method of Manufacture	coiled
Temper	coarse grit up to 9 mm. in diameter, water-worn pebbles
Thickness	8-15 mm., lip thinner
Texture	coarse
Hardness	2.0-3.0
Color	exterior and interior buff to orange, gray occurs, core gray
Lip	flattened
Rim	thinned and slightly flaring, cord marks vertical lip
Body	straight to slightly flaring sides; exterior usually cord marked, cord marks sometimes smoothed, fabric impressed rare; interior usually cord marked, sometimes fabric impressed, sometimes smooth
Base	rounded?
Decoration	none

Marion Thick Type, Iowa

Paste:

Method of manufacture: Coiled

Tempering: Coarse grit. Crushed rock in fragments often exceeding 0.2 or 0.3 cm. in diameter.

Texture: Coarse. Sherds were granular and sandy. Temper showed through the vessel walls.

Hardness: 2.0 to 2.5. Sherds were soft and friable.

Color: Yellow-orange or red-brown, but might range to dark brown or gray. Interior surfaces often black. Cores colored on exterior.

Surface Finish: Cord-wrapped paddle roughened on exterior. Some sherds evidently were textile impressed. Small areas of cord marking appeared on the interior, especially on the inner rim.

Decoration: None.

Form:

Lip: Flat.

Rim: Straight.

Shoulder: Evidently slight to no shoulder expansions.

Body: Probably deep jar.

Base: Unknown, probably conoidal.

Thickness: Lip: 1.0 cm.; Rim: 1.2 cm.; Body: 1.2 to 1.5 cm.

Literature Cited

1. Black, Glenn A. 1932. The Archaeology of Greene County, Ind. Hist. Soc. Bull. X, No. 5.
2. Cole, Fay-Cooper, and T. Deuel., 1937. Rediscovering Illinois, pp. 48-49.
3. Cole, Fay-Cooper. 1951. Kincaid: a pre-historic Illinois metropolis. pp. 184-210.
4. Deuel, T. 1958. American Indian Ways of Life, Ill. State Museum.

5. Faulkner, Charles. 1961. An Archaeological Survey of Marshall County Indiana. M.A. Thesis, Indiana University.

6. Griffin, James B. 1943. "Adena Village Site Pottery from Fayette County Kentucky." Univ. of Ky. Reports in Anthrop. and Archaeol. V, No. 7: 667-670.

7. Griffin, James B. 1945. "Hhe Ceramic Affiliation of the Ohio Valley Adena Culture.

8. Griffin, James B. 1952. Some Early and Middle Woodland Pottery Typies in Illinois. Sci. papers Ill. State Mus. V, No. 3.

9. Helmen, Vernon R 1950. Archaeological Survey of Owen County, Indiana. Ind. Hist. Bur.

10. Helmen,Vernon R. 1960. The Cultural Affiliations and Relationships of the Oliver Farm Site, Marion County, Indiana. M.A. Thesis, Indiana University.

11. Helmen, Vernon R. 1952. Archaelogical Survey of Vigo County, Indiana. Ind. Hist. Bur.

12. Willis, Roger K. 1941. "The Baumer Focus." In: The Society for American Archaelogy, Notebook II, No. 2, p. 28.

Climatic Change and the Northern Plains Archaic

Wesley R. Hurt, Indiana University

Until prehistoric man in the Northern Plains became a horticulturist, his livelihood was based upon the exploitation of the natural resources. Since the availability, abundance, distribution, and type of food supply varied with climatic changes, these cycles had a marked effect upon his cultural patterns. For example, during times of severe drought he was probably forced to migrate to regions of higher elevations within the area proper or to the peripheries where different climatic conditions prevailed.

In order to analyze the relationship between climatic changes and the "Archaic" cultural complex in the Northern Plains, several arbitrary definitions and assumptions are necessary. The term "Archaic" as applied originally in Eastern United States referred to those archaeological sites marked by ground and polished stone tools (14). Krieger has noted that the earliest phase, however, was characterized by food grinding tools, such as milling stones, which have surfaces altered from use, not from deliberate grinding and polishing (23). By now, however, the term has been extended to refer to all those cultures, regardless of tool types, that existed in time between those Paleo-Indian cultures (prior to about 10,000 years ago) and 2,000 years ago, when according to Griffin there was a ". . . gradual change from the initial hunting cultures to the Woodland groups, who had a more stable economic basis and had become more sedentary" (14). In addition, the Archaic peoples, in contrast to the earlier Paleo-Indians exploited a greater variety of natural food products, especially plants. On the other hand the more recent cultures such as the Late Woodland engaged in a small amount of gardening.

The area here referred to as the "Northern Plains" also must be arbitrarily defined since many boundaries can be chosen. For convenience, this area is considered to be that encompassed by the states of Wyoming, Montana, South Dakota, North Dakota, and the southern half of Alberta and Saskatchewan. Although much of the area is flat or rolling grassland, there are many sections of high mountains, buttes, and deep rocky canyons within this state. During prehistoric times, the area as a whole was primarily exploited by hunters of big game animals with gardening confined to some of the major river valleys.

Unfortunately the lack of research makes it impossible to reconstruct the climatic cycles during the past 10,000 years of the Northern Plains on the basis of evidence from this region alone. It is, therefore, necessary to utilize evidence from other regions of the world where more data is available. That such a procedure is feasible is based upon the increasing evidence that the major fluctuations in average thermal levels were and are world-wide in scope. One of the broadest and most detailed studies of climatic cycles is that of Fairbridge, based upon the fluctuating sea levels along stable coastlines (8). The levels of the oceans, the-

oretically, are very sensitive to thermal changes since they reflect the relative amount of water trapped in the form of ice on land as well as that retained in the basins of the seas. It is assumed that in general during cold cycles the levels of the ocean are lower than during thermal maximums.

As yet no attempt has been made to correlate the thermal cycles as revealed by sea levels with the climatic changes of the Northern Plains. Therefore, the relationships here postulated can be considered unproven even though in some instances there is local evidence to support them. With these reservations in mind the writer utilizes these equations: low ocean levels—thermal minimums—moist conditions in Northern Plains—large herds of grazing animals—optimum conditions for hunters. From the point of view of man, however, this equation was the reverse prior to about 7,000 years ago when the climate was too cold and resulted in a large part of the area being covered with continental and mountains glaciers and other ice masses. Another possible exception is the exact time range of sea level changes and climatic shifts for the world as a whole. For example, thermal maximum may have resulted in drought conditions in the Southern Plains sooner than in the North because of the close relationship between locations of wind belts and amounts of of rainfall.

The extent to which a drought for the Northern Plains was reflected in unfavorable conditions for man in a particular local area can not be generalized. Thus, drought may have lessened the water supply on the grasslands, but in mountains areas there still may have been enough permanent water to provide refuges for man. Therefore, man did not necessarily have to completely migrate from the Northern Plains, even during times of extreme drought. Yet it is difficult to believe that for the area as a whole a severe drought of long duration did not result in an actual shrinkage of population, and vice versa when opposite conditions prevailed. The drought in the 1930s drove people out of the Texas and Oklahoma Panhandle regions although not out of all parts of these states.

Moist and Cold Cycle, 10,000-7,600 Years Ago (8,000-5,600 B.C.)

During this cycle large masses of continental ice sheets and glaciers receded northward, leaving in their place large temporary lakes such as Lake Dakota and Lake Agassiz. By 7500 the temperatures had warmed to the extent that Lake Agassiz had dried up. All during the period, however, large portions of the area between the Rocky Mountains and the Missouri were probably ice-free.

Several camp sites have been excavated in the foothills areas of Wyoming, Montana, and western South Dakota. Judging by the large projectile points, which have basically a lanceolate shape, the economy was based upon the hunting of large game animals, in particular bison that were bigger than the present species. The presence of grinding tools, such as muller, indicates that wild vegetable products were also exploited.

Several of the sites, such as the Finley, Cody, and Horner sites in western Wyoming, include the typical stemmed points of the Scotts-

bluff and Eden types (15, 16). The latter site has been dated by radiocarbon analysis at 6,920 ±500 years ago (20, 21, 25). Other examples are the Long Site on the south edge of the Black Hills with dates ranging from 9,380 ±500 to 7,073 ±300 years ago (6, 17, 25) and the Agate Basin site of eastern Wyoming dated at 9,990 ±450 to 9,350 ±450 years ago (26, 23).

Drought Cycle, (?) 7,000-6,000 years ago
(5,000-4,000 B.C.)

According to Fairbridge's Chart, the level of the ocean was still lower than at present, even though rising, an event theoretically correlated with moist conditions in Northern Plains (8). However, no archaeological site has been excavated in this area that is known to date from this period, a possible indication that unfavorable drought conditions had already ensued. Such conditions are not necessarily inconsistent with Fairbridge's Chart in spite of the time discrepancy, or lag. As previously mentioned the thermal changes that are of world-wide scope do not necessarily affect all local areas simultaneously because of the amount of time necessary for wind belts to shift their location. The lack of sites may also indicate no more than a lack of success by the archaeologists in finding them. Along the peripheries of the area, nevertheless, several sites dating from this time period have been excavated. For example, in eastern Nebraska, the second oldest occupation level of the Logan Creek site was dated at 6,663±300 (6). At this site the shallow side-notched projectile points do not closely resemble those from the Northern Plains but are more similar to those from the Simonson Site, 13CK61, of northwest Iowa, dated at 8,430 ±520 (9).

Warm Dry Cycle, 6,000-4,800 years ago
(4,000-2,800 B. C.)

During this cycle the levels of the oceans for the first time since the reteat of the glaciers attained levels higher than that of present (8). According to the assumed correlations, warm dry conditions characterized the Northern Plains. In other regions of the world this thermal maximum has been noted and referred to as the "Hypsithermal" (5), "Altithermal" (1), and "Climatic Optimum." This warm period, postulated by Fairbridge, does not correlate perfectly with the durations of the thermal maximum from other areas of the world referred to by these names. Fairbridge thermal cycle from 6,000-4,800 years ago and others that follow should be considered only as the fluctuations, for example, for the entire period of the "Altithermal" from 7,000 to 4,500 years ago when the temperatures **averaged** higher than present (1).

The sites that so far have been dated as falling within this period all lie in the foothills of the Rocky Mountains where springs probably still flowed in spite of general dry conditions. Apparently the hunting cultures referred to as the "McKean" complex made their appearance during this period. The diagnostic artifact, a lanceolate point with a concave base, is similar in shape to some of those dating prior to 7,000 years ago, although they are smaller in average length.

Sites which have levels containing artifacts of the McKean complex that have radiocarbon dates in this time period include the Grey-

Taylor site (48J0301) in the Middle Fork of the Powder River, Big Horn Mountains, Wyoming, with a time range of 5,230±185 to 4,750± 180; the nearby Sween-Taylor site (48J0301) with the date of 5,030± 150; and the deep hearth at the Rigler Bluff site (24PA68P), north of Yellowstone Park with an average age of 5,040±150 (11, 12, 13).

Cool, Moist Cycle, 4,800-4,000 years ago
(2,800-200 B. C.)

During this short period, Fairbridge's Chart shows the level of the ocean to be slightly lower than at present, indicative of improved living conditions in the Northern Plains (8). In the northern fringes of the plains the water-logged areas which remained from the continental ice sheets had gradually dried up so that by now the area had become attractive to man. This environment is reflected in the wider distribution of the McKean complex and other related groups of hunting cultures. The presence of grinding tools such as mullers and handstones indicates, however, that the collecting of wild vegetable products remained important.

At the previously mentioned rockshelters of Wyoming occupations containing artifacts of the McKean complex have dates that fall within this time range (11, 12, 13). By the end of this period apparently the McKean complex had spread eastward to the Black Hills. For example, the Grant Site (39ME9) in the northern foothills of these mountains has a date of 4,130±130 years ago in addition to the typical McKean lanceolate projectile points which include the stemmed indented based type known as "Duncan points," mullers, and handstones (18, 32). In the Angostura Basin in the southern foothills the McKean type of points were found at Site 39FA68153 and 39FA68-145 which had composite dates ranging from 4,230±350 to 3,630±350 years ago (7).

A slightly different cultural complex of this period is represented at the Powers-Yonkee site (24PR5) of southeastern Montana, which has a date of 4,450±150 years ago. Here bison were driven up a dead-end gully where they were trapped and killed. Bison skulls from this site indicate that this animal was larger than the present-day variety. Typical projectile poins were elongated and had side-natched indented bases (3).

In the Souris River Valley in southwest Saskatchewan, the oldest occupation level, (No. 9) of the Long Creek Site, dated at 4,993 years ago (3,043±125 B. C.), was associated with at least the inception of this period. The few artifacts found prevent comparison with other cultural complexes of the region (31).

Warm, Dry Cycle, 4,000-3,400 years ago
(2,000-1,400 B. C.)

The high ocean levels for this period, as shown on Fairbridge's Chart, may indicate a return to warm dry conditions in the Northern Plains. Evidence for drought condition has been noted by Wettlaufer at the Mortlach site in south central Saskatchewan, where the oldest artifacts occur in a layer of sand overlying clay, the latter probably deposited during the earlier more moist cycle. This culture, named the

"Thunder Creek," is dated at 3,400±150 years ago (30). The main projectile point type, an indented base steemed variety, is reminiscent of the Duncan type of the McKean cultural complex.

Other than the sites on the northern fringe area few have been located in the Northern Plains proper, and those that have been found with the earlier type of points such as McKean Lanceolate are rare. Instead the major type becomes the smaller corner-notched varieties such as Hanna points (32), as found in upper levels of the previously described site (39J030) of the Big Horn Mountains, dated at 3,750±167 (13).

Cool, Moist Cycle, 3,400 to 2,500 years ago
(1,400-500 B.C.)

A period of lower ocean levels (8) that may correlate with cooler and more moist conditions in the Northern Plains. Comparing this cycle with Antev's climatic scheme, it corresponds with the postulated cool phase at the onset of the "Medithermal" (1). Sites are widely distributed in the Northern Plains at this time and are often characterized by corner-notched projectile points such as the Hanna type. The moist conditions may have created an expansion in the grasslands and indirectly resulted in a great increase in the bison herds. The technique of killing bison by driving them over cliffs may have begun at this time.

At the original McKean Site in eastern Wyoming, the artifacts of the McKean complex underly a level with side-notched and corner-notched points of the Hanna types dated at 3,287±600 (27). Wheeler has indicated also that while overlap exists, the Hanna types seems more recent (32). For example, at the Mulehead Creek Site (48CK204), northeastern Wyoming, a level dated 850 B.C. (2,800 years ago) (25) contained Duncan, McKean, and Hanna points; while at the Belle Rockshelter (48CK4) in the same general area, only the Hanna types were encountered.

At the Mavrakis-Bentzen Bisop Trap Site (48SH311) in northeast Wyoming, dated 2,600±200 years ago, there were a few McKean Lanceolate points, but the majority were a long basal-indented, side-notched type (4). Hanna projectile points were also found in Level 5, Long Creek Site in Saskatchewan, dated 1,413±115 B.C. (3,363 years ago) (31). At this site confirmation that this was a moist cycle is indicated by the association of this date with clay and silt layers.

Evidence for killing bison by driving them over cliffs is indicated at the Lance Creek Site of southwest Wyoming dated at approximately 2,500 years (500 B.C.) according to George Agogino *(personal communication)*.

Warm, Dry Cycle, 2,500-2,000 years ago
(500-1 A.D.)

During this period there seems to have been a return to another thermal maximum, indicative of warm dry conditions. Evidence is found in the Abrolhos High sea level (83 and in an erosional disconformity at the Long Creek Site in Saskatchewan (31). This cycle also encompasses the Fairbanks Drought of the Southwest as described by Antevs (2).

Other than in the northern fringe of the area, where extreme drought conditions may not have prevailed, few sites from the Northern Plains have been described as yet as falling unquestionably into this period. A deep firepit at the Good Soldier Site (39LM238) in the Missouri Valley of central South Dakota has a date of 2,380±150 (6). Neuman, who excavated the site, does not consider that the artifacts of the Woodland complex are necessarily associated with either the fireplace or such an early date. He notes also that the potsherds and other artifacts are comparable to those found on Woodland sites of the Missouri Valley and Central Plains that range in time from 400-1,000 A.D. (28).

At the Long Creek Site there is an unconformity separating the lower Level 5 with the Hanna occupation from the upper Level 4 of the Pelican Lake culture dating at 293±100 B.C. (2,343 years ago) (31). Characteristic of the Pelican Lake complex are corner-notched points with straight or convex bases. At the Mortlach Site the levels containing the Pelican Lake Complex, dated at 2,400±290 years ago also are marked by sandy deposits indicative of drought (30).

Climate Like that of Present, 2,000-1,600 years ago
(1 A.D. to 350 A.D.)

Although the levels of the ocean apparently were slightly higher than those at present, this difference was so minor that the climate was about the same as today (8). This period seems to have been correlated with a marked expansion of bison herds correlated with the wide distribution of the "buffalo jump" sites, that is areas where bison were killed by driving over cliffs. One example of a site of this type that has been dated is the Old Women's Buffalo Jump south of Calgary, Alberta, where the two lower levels had a time span from 1,840±70 to 1,650±600 years ago (10).

The eastern part of the Northern Plains at this time also witnessed the introduction of the Woodland cultural complex from eastern United States, marked by the presence of ceramics and burial mounds. Few of these sites have been dated, but the age of 397±180 from the Sherman Park Mounds near Sioux Falls, South Dakota, supports such a contention (19).

Summary

As a possible yardstick for correlating the cultural and climatic changes in the Northern Plains during the "Archaic" stage (10,000-2,000 years ago), the chart showing the changing ocean levels, made by Fairbridge was utilized (8). Such a procedure was necessary since there has not been sufficient geological research in the Northern Plains to reconstruct the past climatic cycle on the basis of local evidence alone. It is assumed that during this period the following relationship existed: low sea levels—low temperatures—moist conditions for the Northern Plains as a whole—expansion of grasslands—expansion of herds of grazing animals—most favorable conditions for human populations which expanded as a result and vice versa. During unfavorable conditions, that is drought, the populations moved to less effected areas on the peripheries or to regions of higher elevations within the Northern Plains where there may have been permanent streams and springs.

Literature Cited

1. Antevs, Ernst, 1948. The Great Basin, with Special Emphasis on Glacial and Post-glacial Times, III, Climactic Changes and Pre-White Man: University of Utah Bulletin. **38.** No. 20, pp. 168-191.
2. Antevs, Ernst. 1955. Geologic Climatic Dating in the West, American Antiquity, **20,** No. 4, pp. 317-355.
3. Bentzen, Raymond. 1962A. The Powers-Yonkee Bison Trap, Plains Anthropologist **7,** No. 16, pp. 113-118.
4. Bentzen, Raymond, 1962B. The Mavrakis-Bentzen-Roberts Bison Trap, 48SH311. Wyoming Archaeological Society, Sheridan.
5. Cooper, W. S., 1958. Terminology of Post-Valders Time, Geological Society of America Bulletin, **69.** pp. 941-945.
6. Crane, H. R. and James B. Gri..n, 1962. University of Michigan Radiocarbon Dates VII, from Radiocarbon **4.** Yale University, pp. 183-203.
7. Crane, H. R., 1956. University of Michigan Radiocarbon Dates, I. Science 124. pp. 664-672.
8. Fairbridge, R. W. 1960 The Changing Level of the Sea. Scientific American **202.** N. 5, p. 109.
9. Frankforter, W. D., and George A. Agogino, 1960. The Simonson Site: Report for the Summer of 1959, Plains Anthropologist **5.** pp. 65-70.
10. Forbis, Richard G., 1960. The Old Women's Buffalo Jump, Alberta. Contributions to Anthropology, Pt. 1, National Museum of Canada, Bull. No. 180.
11. Grey, Donald, 1959. Wyoming Archaeologist II, No. 6, pp. 1-4.
12. Grey, Donald, 1960. Wyoming Archaeologist III. Nos. 11-12- p. 3.
13. Grey, Donald, 1962. Radiocarbon Date List, No. 1, September, 1962, Sheridan College, Sheridan, Wyoming (dittoed manuscript).
14. Griffin, James B. 1964. The Northeast Woodlands Area from Prehistoric Man in the New World. Rice University, pp. 223-258.
15. Howard, Edgar B., 1943. The Finley Site: Discovery of Yuma Points, in situ, near Eden, Wyoming. American Antiquity VIII, No. 3, pp. 224-234.
16. Homard, Edgar B., Linton Satterthwaite, Jr., and Charles Bache, 1941. Preliminary Report on a Buried Yuma Site in Wyoming. American Antiquity VII. No. 1, pp. 70-74.
17. Hughes, Jack T., 1949. Investigations in Western South Dakota and Northeastern Wyoming. American Antiquity XIV, No. 4, pp. 266-278.
18. Hurt, Wesley R., 1960. A New Radiocarbon Date from South Dakota, Museum News, Vol. 21, Nos. 11-12. University of South Dakota, pp. 1-3.
19. Hurt, Wesley R., 1963. The 1962 Excavations of the Sherman Mound Site, 39Mn8, A Newly Radiocarbon Dated Site in South Dakota, Museum News 24. No. 1, pp. 1-4.
20. Jepsen, Glenn L. 1951 Ancient Buffalo Hunters in Wyoming. News Letter No. 24. Archaeological Society of New Jersey. pp. 22-24.
21. Jepsen, Glenn L., 1953a. Ancient Buffalo Hunters of Northwestern Wyoming. Southwestern Lore 19, No. 2, pp. 19-25.
22. Johnson, Elden and C. T. Shay (unpublished manuscript), The Southern Lake Agassiz Basin. 20th Plains Conference Symposium on Pre-ceramic Cultures.
23. Kreiger, Alex D., 1964. Early Man in the New World, from Pre-historic Man in the New World. Rice University, pp. 23-81.
24. Kulp, J. Laurence et al, 1951. Lamont Radiocarbon Measurements, I, Science 114, No. 2970, p. 566.
25. Libby, W. F., 1952. Chicago Radiocarbon Dates, III, Science **116.** No. 3025, pp. 673-681.
26. Libby, W. F., 1955. Radiocarbon Dating. 2nd ed. The University of Chicago Press.
27. Mulloy, William, 1954. The McKean Site in Northeastern Wyoming, Southwestern Journal of Anthropology **10,** No. 4, pp. 450-461.
28. Neuman, Robert W., 1965. The Good Soldier Creek Site (39LM238), Big Bend Reservoir, Lyman County, South Dakota, River Basin Surveys Papers, No. 37, Bureau of American Ethnology, Bull. 189. pp. 291-318.

29. Roberts, Frank H. H., Jr., 1943 A New Site in Notes and News. American Antiquity VIII, No. 3, p. 300.

30. Wettlaufer, Boyd N., 1955. The Mortlach Site in the Besant Valley of Central Saskatchewan, Anthropological Series No. 1, Saskatchewan Museum of Natural History.

31. Wettlaufer, Boyd and William J. Mayer-Oakes, 1960. The Long Creek Site, Anthropological Series No. 2, Saskatchewan Museum of Natural History.

32. Wheeler, Richard P., 1954. Two New Projectile Point Types: Duncan and Hanna Points, The Plains Anthropologist, No. 1, pp. 7-10.

Some Institutional Response to Culture Contact

Edwin O. Segal, Indiana University

The impact of Western culture on Africa has often been thought of as a process in which old institutions are destroyed and replaced by new ones. This is, of course, an over-simplification generally used for analytical purposes. In actuality these traditional institutions are not destroyed, in the sense that they cease to exist. Rather, they undergo changes in scope and function. It is my purpose to examine here three tradtional Yoruba political institutions and analyze the changes that have taken place under the establishment of British rule.

The term "Yoruba" does not refer to a single, relatively homogeneous society. The Yoruba are divided into several provinces, chiefdoms, districts and semi-autonomous villages, all of which show a measure of cultural divergence one from the other.

Forde (7) distinguishes twenty-three different Yoruba chiefdoms all of which were monarchies. However, the Yoruba monarchy was not absolute; there were always a number of checks on its powers. By the same token, no other political body ever had complete political control either.

The degree of differentiation among the various Yoruba "tribes" is greatest in the sphere of political structure (9, p. 368). This is especially true of the institutions that functioned as a check on monarchial power. The largest division is between those Yoruba groups in which age sets were the major check on the king and those in which secret associations were the major check.

I have chosen those groups with secret associations as the major check as the focus of this paper because the position of these institutions in the traditional Yoruba political system is relatively clear, where the position of age sets is not.

Of the twenty-three different chiefdoms, significant amounts of data exist on eight. Of these eight, four have secret associations as the primary counter balance to the chief. The following discussion of both the traditional system and the changes that have occurred is based on a composite of these four sub-groups: Yoruba proper (Oyo, Ibadan and Ilorin), Egba, Ife and Ijebu.

The Traditional System

There are three major Yoruba secret associations: Egungun, Oro and Ogboni. Of these, in the traditional system Egungun is only slightly involved in the political structure; Ogboni is almost totally involved and Oro is peripherally involved, especially through its connections with Ogboni.

In general Ogboni is considered to be primarily a political organization with the following duties: to elect and install kings or chiefs, to legislate, to hear and judge cases and generally "to help the king in the proper government of the country" (1, p. 90).

Aside from these general functions, there is at least one report that Ogboni was also involved in problems of formal social control in that it executed criminals (12, p. 117). However, this is probably a mistake stemming from a confusion of Ogboni and Oro. The ties between the two were relatively strong and there was even an overlapping membership to some extent (6, pp. 68-71).

Oro is the second of the secret associations that were traditionally involved in political activities. Primarily Oro is a religious association whose major function is to represent the ancestors. Oro represents the ancestors as a collective unit (11, p. 141).

Oro's ties with the ancestors provide a supernatural sanction for its non-religious activities. Most of these center in the area of formal social control. That is, Oro is reported as performing specific, expected, institutinalized acts that function to control, punish or correct deviant behavior. For the most part, Oro's social control functions lay in the execution or other punishment of criminals and witches (11, p. 141). Oro is able to punish only those who had been condemned by Ogboni.

It is clear that Oro is associated with Ogboni and its political functions. However, this association probably stems from the fact that Oro, a religious association, by acting as executioner lends supernatural sanction and support to the decisions and actions of Ogboni. There is no evidence of Oro acting as an independent political agent.

The third association, Egungun, had, at the most, a minor role in the traditional political system. However, it has been reported to have taken both an interesting and important place in the modern political scene.

Like Oro, Egungun is primarily a religious association drawing on a relationship to the ancestors. However, where Oro represents a collectivity of ancestors, Egungun members represent individual ancestors, though not specifically known ones, who have come back to life to dance and parade through town and to make known their will (6, pp. 76-81).

Besides its religious activities, Bascom (2) reports a minor part in the political system. This is confined mainly to the area of social control and consists largely of what might be termed a "show of strength" on the part of the ancestors. Apparently, this show serves to reinforce the belief in the concern of the ancestors and the power they can wield if displeased. It also seems that at one time this was more than a show of potential power; that is, Egungun actually punished those who had displeased the ancestors who they personified (12, pp. 105-119; 5).

The Traditional Institutions Today

In discussions of the present-day roles of traditional political institutions Oro disappears. Its punishment functions have been taken over by a regularly constituted police force. There is one report that the Native Authorities, as recognized by the British generally maintain the provincial police forces (8, p. 125). However, the extent to which these overlap in membership with Oro is unknown and, given Oro's super-

natural base, probably non-existent. Also the extent of Oro's survival as a religious institution representing the collective will of the ancestors is unknown.

Ogboni, on the other hand, still exists in a number of forms in the various kingdoms. Among the Ijebu it still maintains some political functions. The town councils are now elected by the representatives of various associations, among them Ogboni (8, p. 117). This is actually close to the traditional system of selection to the chief's council, except for the fact that different criteria of recruitment were used (age, wealth and prestige). However, the major difference is that the authority sanctioning the operation of the council derives from a non-traditional secular force.

Perhaps the most important change in Ogboni is the development of the Reformed Ogboni Fraternity. This association is, like its traditional predecessor, extremely important in politics. However, this importance does not stem, as with Ogboni, from supernatural sanctions (10, p. 26). Rather it stems from the economic, educational and social prestige of its members. Furthermore, the traditional formal powers are gone. Important as it is, there is relatively little information on the Reformed Ogboni Fraternity. What is known is that it is a deliberately created group based on a combination of Freemasonry and traditional Ogboni in an attempt to depaganize its rituals and make them acceptable to Muslims and Christians (4, p. 34).

Finally, there is a recent report of the entrance of Egungun into political life. This apparently stems from a slightly earlier extension of its social control activities to social criticism. In a report of an election campaign in a Yoruba town, Beier notes that periodically Egungun members appeared representing the spirits of the two contending parties, the Action Group and the N.C.N.C., and that the dances and songs of these masqueraders are used as an opportunity to present topical political messages (3, p. 68).

Conclusions

The changes in the traditional political system that have been discussed, all too briefly, here seem to show a particular pattern of institutional responses to a culture contact situation.

It should be noted that most of the changes that have occurred are not demonstrably the result of westernization. Rather, they are the direct result of British adminstrative policy.

Oro is the association whose political position has been most disturbed. As noted earlier, there are no reports of Oro taking independent political action. The society depended on a mandate handed down by Ogboni. Deprived of this mandate, Oro could no longer function as an executioner.

In the case of Ogboni the changes that have taken place are of a much more subtle sort. Although the British undermined the society's formal powers by setting up an alternative judicial system, the composition of its membership was not affected. This still included the most prestigeful men in the city. Gradually Ogboni experienced a change of

focus. Where it was once a primarily political body, it has become primarily a recreational association of people of high status. As a recreational organization one of its primary spheres of activity seems to be as a mutual aid association. In this respect the surviving Ogboni is quite similar to the new Reformed Ogboni Fraternity which, as a combination of traditional Ogboni and Freemasonry, is primarly a recreational and mutual aid association.

A word should also be said about Ogboni's present political role. This seems to be a result of the fact that the society is still an avenue for prestige and attracts individuals of high status and influence. It has become, then, a parapolitical organization much like the Chamber of Commerce in the United States on both a national and local level.

The most surprising aspect of change in the traditional political system is the emergence of Egungun as a political force. It is important to note that Egungun's new political role is unlike any political role in traditional society. This is, of course, in part related to the fact that political parties did not exist in traditional society. However, it is also possible to view this function as the promotion of a particular ideology, in this case a political one. This sort of promotional organization was also traditionally unknown.

One factor stands out in these three different responses to the impact of colonialism. Oro, the association with the most specific traditional political function, lost that function and disappeared from the political scene. On the other hand, Egungun, the association with the most diffuse and perhaps smallest part in the traditional political system not only survived as a political force, but also seems to have emerged as what may well prove to be a strong link between traditional society and the modern political system. Finally, between these poles stands Ogboni, the society with several specific and some diffuse political responsibilities. Here, the association has lost its formal powers, but has maintained its political influence by subordinating a formerly primary role to a formerly secondary role, that of mutual aid society operating for the benefit of its members.

What is suggested by this is that in investigating the impact of western domination and the impact of continued westernization, a continuum ranking the specificity and diffuseness of the functions of various institutions might prove to be a useful research tool. It also suggests the hypothesis that the more specific the political functions of a given institution, the less resistant it is to the impact of an invading political system. This could also be generalized by eliminating the word "political" and by substituting "invading culture" for "invading political system." Also, the connections between Oro and Ogboni suggest that changes in some institutions may be dependent on changes in, or capacity for change in other institutions.

Finally, these conclusions have a bearing on applied anthropology. They suggest that if the emergent nations wish to make use of traditional institutions and turn them toward more "modern" goals and functions, a greater measure of success can be expected if traditional institutions with more generalized functions are utilized, rather than

institutions with highly specific functions. Needless to say, this whole area is in need of extensive further research.

Literature Cited

1. Ajisafe, A. K. 1924. The Laws and Customs of the Yoruba People. London.
2. Bascom, W. R. 1944. The Sociological Role of the Yoruba Cult-Group. American Anthropologist **46**, No. 1, part 2.
3. Beier, U. 1960. Transition Without Tears. Encounter **15**, 4:65-68.
4. Biobaku, S. O., et al, eds. 1949. Ibadan. Ibadan.
5. Dennett, R. E. 1916. The Ogboni and Other Secret Societies of Nigeria. Journal of the African Society **16**: 16-29.
6. Farrow, S. 1926. Fact, Fancies, and Fetich. London.
7. Forde, C. D. 1951. The Yoruba-Speaking Peoples of South-Western Nigeria. London.
8. Hailey, Lord. 1951. Native Administration in the British African Territories, Part III. London.
9. Lloyd, P. C. 1954. The Traditional Political System of the Yoruba. Southwestern Journal of Anthropology **10**:366-384.
10. Morton-Williams, P. 1953. The Social Consequences of Industrialism Among the South Western Yoruba. Ibadan.
11. Parrinder, G. 1949. West African Religion. London.
12. Webster, H. 1908. Primitive Secret Societies. New York.

The Social Organization of the Northeastern Algonkians

Jack A. Frisch, Indiana University

The Northeastern Algonkian Indians are those ethnic units who speak mutually intelligible dialects of the Algonkian language family, and inhabit the lands of eastern Canada and northern Maine. Driver (3) assigns these ethnic units to the Eastern Sub-Arctic culture area. Included among these people are the following groups: the Abnaki (including the Penobscot), the Malecite (including the Passamaquoddy), and the Micmac. The Northeastern Algonkians inhabit an area that, in aboriginal times, supported a hunting economy. The aboriginal mainstay of the area was the hunting of large game animals like caribou and deer. Cooper (1) ascribes these ethnic units to three ecological areas: in the north, caribou was the principal means of subsistence; moving a little to the south, sedentary fur-bearing animals are found in addition to deer and woodland caribou; in the southernmost ecological area, hunting as the main source of subsistence was supplemented in varying degrees by maize cultivation. The climate of this area ranges from a sub-arctic climate with temperatures rarely rising above 50° Fahrenheit in the northern section to a humid-continental climate with cool summers in the southern portion. This kind of climate, along with the natural land base, sustains a coniferous forest covering. The flora and fauna of this region was capable, in aboriginal times, of supporting a simple hunting economy; this level of subsistence was a determining factor in the social organization of the inhabitants of the area.

Because of the reliance upon the fauna as the principal means of subsistence, the Abnaki, Malecite, and Micmac were organized in such a manner that hunting could be performed more effectively. To accomplish efficiency in hunting, the Northeastern Algonkians were organized along family lines into what Speck (7) calls the family hunting group or band. Speck defined the family hunting band as a kinship group "composed of folks united by blood or marriage, having the right to hunt, trap, and fish in a certain inherited district bounded by some rivers, lakes, or other natural landmarks (7:290)." One feature of the band organization of the Northeastern Algonkians is the incidence of ambilocal residence; that is, the members of one band were able to shift their residence to that of another band, as long as there was some demonstrable genetic or affinal tie between the groups. It is this latter fact that has led me to characterize the social organization of these Indians as demes. The introduction of several new concepts and the application of these concepts to the social organization of the Northeastern Algonkian Indians allows the anthropologist to compare the organizational structures of these Indians with the kinship organization of other ethnic groups throughout the world.

The fact that the social organization of the Northeastern Algonkians is based upon cognatic ties rather than upon unilinear rules is

not new, however, former descriptions of the social organization of these people are inaccurate and often misleading. Driver postulates bilateral descent for all of the Northeastern Algonkians, however, he ascribes patrilocal residence for the area (3). Devereaux (2), following Driver, ascribes patridemes to the tribes of the area, thus assigning them patrilocal residence. If Driver's functional theory (4) is tenable, then the clustering of certain traits would demonstrate that ambilocality is more compatible with bilateral descent than any form of unilocal residence. In my analytical models presented elsewhere (5, 6), bilateral kinship structures are characterized by small domestic family units, ambilocal or neolocal residence, the importance of the kindred as a functioning social unit, community groups structured as demes, Eskimo cousin terminology, and lineal or bifurcate collateral avuncular terminology.

While it is apparent that the "ideal" bilateral society is not present among the Northeastern Algonkians, their social structure is closer to being bilateral than it is to any other type of kinship organization. The small domestic family is the basic unit of Northeastern Algonkian social organization. On the level of the intermediate kin group the kindred is a functional unit. The community structure approximates that of a deme, with an ambilocal rule of marital residence in operation. Only the kinship terminology deviates from the model; bifurcate collateral avuncular terms are present among the Abnaki and Malecite, while the Micmac possess lineal avuncular terms. Hawaiian cousin terms are found among the Abnaki and Malecite, while the Micmac have an Eskimo cousin terminology.

It has been impossible in these few lines to present all of the ethnographic evidence supporting my use of the deme as the unit of social organization among the Northeastern Algonkians; the reader is referred to earlier works of mine in which I have demonstrated the validity of the concept of the deme (6) and its application to the Northeastern Algonkians (5).

Literature Cited

1 Cooper, A. 1942. Ecological Aspects of the Family Hunting Territory System of the Northeastern Algonkians. M.A. Thesis, University of Chicago.

2. Devereaux, J. D. 1960. Social Organization and Land Tenure Among Canadian Indians. M.A. Thesis, Indiana University.

3. Driver, H. E. 1961. Indian of North America. Chicago.

4. Driver, H. E. and W. C. Massey. 1957. Comparative Studies of North American Indians. Transactions of the American Philosophical Society, n.s., **47**:165-456.

5. Frisch, J. A. 1964a. Cognatic Kinship Organization Among the Northeast Algonkians. M.A. Thesis, Indiana University.

6. ————————. 1964b. Cognatic Kinship Organization: Some Theoretical Considerations Proc. Ind Acad Sci. **73**:71-74.

7. Speck, F. G. 1915. The Family Hunting Band as the Basis of Algonkian Social Organization. Amer. Anth., n.s. **17**:289-305.

A Suggested Standardization of Nomenclature in Archaeological Methodology

B. K. SCHWARTZ, JR., Ball State Teachers College

This paper is an attempt to standardize terminology of practical value for methodological use in archaeology. The proposed nomenclature is presented in Table 1. This nomenclature was successfully employed in site report presentation by the writer (1).

TABLE 1

	general	analytical	interpretative
artifact-free, specific	*attribute*	*mode*	*element*
artifact-bound, interrelated attributes	*class*	*type*	*trait*
integrative, attributes and/or classes	*collection*	*complex*	*pattern*

Analysis

To understand the distinctions made in defining these terms the difference between analysis and interpretation must be made clear. Analysis is the procedure whereby archaeological data are placed in a framework of time and space; it is the initial step in the studying of archaeological materials obtained in the field (2). Analysis, as here defined, may be considered to be distinct in its purposes and goals from cultural reconstruction, for which it provides the required temporal-spatial ordering. Analysis, then, can be seen as the manipulation of masses of archaeological data for the purpose of deriving temporal-spatial order. Such order must be accomplished by classification, the procedure by which manipulable units, essential for demonstrating similarities and differences through time and space, are formed (3).

The basic unit employed in archaeology is the *attribute*. An attribute is any quality or aspect of material manifestation that can be ordered or described. As Spaulding points out (4) an "attribute may be one of a continuous group, a measurement of length . . . or a discrete quality, as in the case of observing that an object is made of bone . . . It may be a physical or chemical property—. . . weight, shape, chemical composition, etc." Krieger's term *feature* (5) is equivalent to an attribute.

Attributes that are diagnostic temporal-spatial indicators are here termed modes. The concept of *mode* was introduced into the literature by Rouse (6), and is equivalent to Krieger's *character* (5). Rouse would limit mode to include only attributes with cultural significance, while I would exclude attributes with cultural significance that possessed no

time-space implication. "By the term 'mode' is meant any standard, concept, or custom which governs the behavior of the artisans of a community . . . Analytic classification, then, must single out modes, which are cultural, and exclude those traits [attributes] which are purely biological, chemical, or physical" (7). It is conceivable, though perhaps improbable, that an attribute may have temporal-spatial significance, but no cultural significance. For example, unknown to a community of potters, a microscopically imperceptible alteration might naturally occur in a clay deposit that is microscopically detectable to an archaeologist when incorporated into a pottery form. Such an alteration could quite likely be sensitive to change in time and space. An attribute caused by this clay alteration would have no cultural significance if imperceptible to the potters on a conscious and subconscious level.

Another unit used in archaeology, but seldom formally defined, is a *class*. A class is simply a group of artifacts sorted together as a unit by similarity of appearance. Class as used here differs from Osgood's meaning (3) which is restricted to a group of artifacts manufactured from a single material. Daugherty's term *form* (8) implies that shape or form is the only criteria used, and, therefore, is not employed here. A class that successfully serves as a diagnostic temporal-spatial indicator is a *type*. A type, like a *mode*, need not have cultural significance. This use of the type concept conforms with Steward's Historical-Index Type (9). In essence, a type is nothing more than a related set of recurring artifact-bound attributes. Spaulding (10) and Shepard (11) have implicitly extended the concept of type to include clusterings of attributes, statistically derived, independent of artifact classes. I believe that this does violence to the typological concept and such a term as attribute cluster would be more appropriate.

Archaelogical *collections*, temporally-spatially ordered, are here termed *complexes*. Complexes are portions of phases that share some common mode, or partitive units of such interrelated segments. Braidwood's term *industry*, used in Old World archaeology (12) is similar in concept to complex. Distributions of specific modes and types can also be plotted on these ordinates.

Interpretation

Procedures of interpretation do not actually follow upon the previous objective of time-space framework formulation, but rather start at the same level as analysis, utilizing the additional data of analysis, but directing this data to a different goal. The goal of interpretation is to discover how an assemblage of artifacts was manufactured and used at a certain place and at a specific time, not the ordering of data temporally or spatially. The interpretative procedure must be performed after analysis has identified a temporal-spatial unit, so that an artifact inventory can be determined.

The bulk of direct evidence on cultural evolution has been derived from data interpreted from archaeological remains. Awareness of the value of interpretation is largely incipient, however. This lack of emphasis was pointed out by Steward and Seltzer (13), and was strongly indicted by Taylor (14).

Epistemological considerations of archaeological interpretation have been examined by Thompson (15). Archaeological interpretation is the result of the inferential process which proceeds in two steps, indication and testing. Indication is that activity of making indicated conclusions from observed indicative data. Testing is that activity of making inferences by analogy of indicated conclusions with probative data. The inferential process is operative on the analytic level, but is presented here since it is at the interpretative level that the final results of inference become manifest.

The most reliable probative data is association. From the relative position of two or more objects with one another, or with one or more objects with some significant natural features, valuable probative data can be obtained. For example, if red ocher is found adhering to the grinding surface of a palette, the inference that the palette served as a device for preparing red paint pigment seems plausible. Interpretation of this type corresponds to Taylor's Conjunctive Approach (14).

Less reliable is ethnographic data obtained in the same area as the archaeological materials. Best results of this type of data can be obtained if the archaeological material is not too early in time, and recent conquests and invasions have not occurred in the area. If these conditions are met it can be assumed that there is historical continuity between ethnographic practices and archaeological evidences. Interpretation in this situation has been termed the Direct Historical Approach by Steward (16).

Often local ethnographic data are unobtainable. Attention should then be given to finding ethnographic analogs from societies with similar subsistence levels and habitats. This type of comparison is called the "New Analogy" by Ascher (17). Of course if data of this nature are unavailable other ethnographic data must be relied upon.

If ethnographic data are unavailable or poor, Experimental Analogy (18) can be utilized. Valuable inferences on chipping techniques of paleolithic tools have been obtained in this manner, for example Semenov (19).

The smallest units of interpretative significance are here termed elements. Linton's concept of *item* (20) is comparable. Elements fall into two basic categories, manufacturing techniques and uses of objects. There are three types of manufacturing techniques, (1) selection of materials for manufacture, (2) manufacturing of objects by reduction, that is the removing of matter from an original piece of raw material, and (3) manufacturing of objects by construction, combining raw materials to build a qualitatively distinct form. The analytic counterpart of an element is an attribute.

Uses may be either dynamic, that is a moving action is required in its employment, or static. Also, uses may be utilitarian, that is required to maintain a livelihood, or non-utilitarian. A description of the manufacturing techniques and uses of an assemblage of artifacts is the *techniculture* (3) of a community.

A larger synthetic unit is the *trait.* A trait differs from an element in that a "unit of observation" is implied (21). In archaeology, due to the nature of the materials studied, a trait acquires a more formal

aspect. Traits are simply "functional types," classes of artifacts grouped together on the basis of suspected common use. Functional types seldom coincide with analytic types, defined on temporal-spatial bases.

The basic unit of reconstruction is here called a *pattern.* This concept is similar to Wissler's Universal Pattern (21) and Reed's Culture Category (22). Unlike complexes, patterns must occur at one time and place, that is within a phase as defined by Willey and Phillips (23). The analytic procedure of defining a phase in space and time must precede cultural reconstruction of interpretative data into patterns. A description of the patterns of a phase constitute, essentially, an "archaeological ethnography," or what Taylor would call "historigraphy." (14).

It is my belief that application of the terminology proposed in this paper will provide continuity and uniformity to presentation of archaeological data.

Literature Cited

1. Swartz, B. K., Jr. 1964. Archaeological Excavations at Lava Beds National Monument, California. Ph.D. dissertation, The University of Arizona.
2. Brainerd, G. W. 1951. The Place of Chronological Ordering in Archaeological Analysis. American Antiquity **26**:301-13.
3. Osgood, C. 1942. The Ciboney Culture of Cayo Redondo. Yale University Publications in Anthropology **25.**
4. Spaulding, A. C. 1960. Statistical Descriptions and Comparison of Artifact Assemblages. *In* the Application of Quantitative Methods in Archaeology, R. F. Heizer (ed.), pp. 60-92. Viking Fund Publications in Anthropology **28.**
5. Krieger, A. D. 1944. The Typological Concept. American Antiquity **9**:271-88.
6. Rouse, I. 1939. Prehistory in Haiti: A Study of Method. Yale University Publications in Anthropology **21.**
7. ————————. 1960. The Classification of Artifacts in Archaeology. American Antiquity **25**:313-23.
8. Daugherty, R. D. n.d. The Methodology of Typology (mimeo).
9. Steward, J. H. 1954. Types of Types. American Anthropologist **56**:54.57.
10. Spaulding, A. C. 1953 Statistical Techniques for the Discovery of Artifact Types. American Antiquity **18**:305-13.
11. Shepard, A. C. 1956. Ceramics for the Archaeologist. Carnegie Institution of Washington, Publication 609.
12. Braidwood, R. J. 1946. Terminology in Prehistory *In* Human Origins, Ser. 2, No. 14.
13. Steward, J. H., and F. M. Seltzer, 1938. Function and Configuration in Archaeology. American Antiquity **4.**
14. Taylor, W. W. 1948. A Study of Archaeology. Memoirs of the American Anthropological Association **69.**
15. Thompson, R. H. 1958. Modern Yucatecan Maya Pottery Making. Memoirs of the Society for American Archaeology **1.**
16. Steward, J. H. 1942. The Direct Historical Approach to Archaeology. American Antiquity **7.**
17. Ascher, R. 1961a. Analogy in Archaeological Interpretation. Southwestern Journal of Anthropology **17.**
18. ————————. 1961b. Experimental Archaeology. American Anthropologist **63.**
19. Semenov, S. A. 1964 Prehistoric Technology Cory Adams, and Mackay.
20. Lintton, R. 1936. The Study of Man. Appleton-Century Crofts.
21. Wissler, C. 1923. Man and Culture. Thomas Y. Crowell.
22. Reed, E. K. 1958. Excavations in Mancos Canyon, Colorado. University of Utah Anthropological Papers **35.**
23. Willey, G. A., and Phillips. 1958. Method and Theory in American Archaeology. University of Chicago.

BACTERIOLOGY

Chairman: GORDON MALETTE, American Society for Microbiology
MORRIS WAGNER, University of Notre Dame, was elected president for 1965

ABSTRACTS

Virus-growth in Colchcichine-induced, Micronucleated, Tissue-cultured Cells. THEODORE J. STARR and RICHARD G. CONSIDINE, University of Notre Dame.—The normal mitotic sequence of plant and animal cells can be altered by chemical and physical means. One impressive result of colchicine treatment of certain tissue-cultured cells is the structural disorganization of the interphase nucleus which apparently dissociates into a multitude of smaller units designated as micronuclei. The gross morphological changes associated with the formation of colchicine-induced, micronucleated cells are considered at both the cellular and chromosomal level. A voluminous literature attests to the widespread application of colchicine in biology, medicine, and agriculture. In sharp contrast, the biochemical capacity of micronucleated cells has received little attention. The micronucleated cell may provide a unique environment for study of host-parasite relationships, physiology of cell division and biochemistry of senescence. In this study, growth patterns of the agent of psittacosis, adeno virus, and vaccinia virus, within micronucleated cells, were compared to that obtained in normal cells. Observations were made on preparations stained with acridine orange fluorochrome. The gross cytochemical staining reactions associated with the agent of psittacosis and that of vaccinia within the cytoplasm appeared normal. The nuclear inclusion associated with adeno virus infection was usually present within most of the micronuclei of any single cell. The possible significance of these observations is considered.

Method of Producing a Fungal Immunological Response in Guinea Pigs to Trichophyton mentagrophytes. A. D. Chandler, Jr., Pitman-Moore Research Center, Indianapolis.—The objective of this paper is to describe a procedure for producing dermatophytosis in guinea pigs with a spore suspension of *Trichophyton mentagrophytes*, and to demonstrate an immunological response following reinfection. The course of the infection is described as four phases which occur chronologically as erythema, crdust formation, alopecia, and hair regrowth phase.

The immunological response is demonstrated with slides showing the control pig and the reinfected pig in the four phases of the infection. Demonstration of the immunological response also is presented in a table showing measurements of the lesions in mm diameter at the peak of each of the phases.

The immunological response in guinea pigs to reinfection with *T. mentagrophytes* is characterized by a greater inflammation of shorter duration and smaller lesions of shorter duration than with the first infection.

The Toxicity of Azathioprine (Imuran) in Germfree ICR Mice. G. R. FITZGERALD and M. POLLARD, Lobund Laboratory, University of Notre Dame.—Azathioprine is an analog of 6-mercaptopurine developed by Burroughs Wellcome and Co. as a possible chemo-therapeutic agent in the control of cancer. Preliminary work on its toxicity performed in this laboratory indicated a greater susceptibility among germfree ICR mice than among comparable conventional animals. Eleven daily injections, i.p., of 250 mg/kg of the drug in germfree animals were required to reduce the number of survivors to practically zero, whereas fourteen daily injections of the same dose were required in the conventional animals for the same effect. Moreover, under any given regimen of dosage, the germfree animals died, on the average, earlier than did the conventional animals. Possibly the germfree animal is more susceptible to azathioprine because it lacks a factor or factors provided to some extent by the microbial flora of the conventional animals. The germfree animal thus provides an advantage in studies of the pharmacologic effects of drugs. We anticipate that further study of the action of this compound in germfree animals may provide a clue as to its mechanism of action.

The Effect of the Successive Administration of Two Antigens to Germfree and Conventional Chickens

B. S. Wostmann and G. B. Olson, Unversity of Notre Dame

In the germfree chicken, the lymphoid tissue has never been exposed to the multiple stimulating effects of a viable microflora. Less lymphoid tissue is found, which contains fewer plasma cells and secondary nodules (1). Upon stimulation with a single dose of bovine serum albumin (BSA), less precipitating antibody is formed. The data indicate, however, that this antibody formation continues after maximum serum antibody concentrations are reached. In the conventional chicken, on the other hand, precipitating antibody production practically ceases at this point (2). The persistence of antibody formation in the germfree bird was explained by the assumption that in the absence of major antigenic stimulation originating from a viable microflora, the antigenic effect of the BSA on the antibody producing cellular elements persisted. To test this hypothesis, BSA stimulated germfree and conventional chickens were administered a second unrelated protein antigen, human gamma globulin (HGG), just before the anti-BSA antibody concentration reached its maximum value. The results indicate that the administration of this second antigen (HGG) terminated the prolonged production of antibody against the first antigen (BSA). They also show that under these conditions the antibody response to the second antigen is depressed.

Materials and Methods

Adult 90-110 day old male and female white Leghorn chickens of germfree and conventional status were obtained from the same egg clutches. Germfree birds were housed in plastic isolators with approximately 1100 square cm of floor space per bird. The conventional controls were housed in equivalent floor space but in an open room environment. All birds were fed diet L-289F ad libitum (3).

Germfree and conventional chickens were injected with a single dose of 40 mg of the antigen, either BSA or HGG, via the cubital vein. When two antigens were administered, BSA was given first, followed 7 days later by HGG. The animals were bled on subsequent designated days from the cubital vein to obtain 0.5 ml of chicken plasma. Experimental series I (BSA only) was conducted earlier, series II (BSA, HGG and BSA + HGG) was conducted at a later date.

Precipitating antibody directed against BSA or HGG was determined with a modified Preer technique (2, 4). Half value times (the time needed to reduce a given antibody concentration to half its original value) of anti-BSA and anti-HGG antibody were calculated from the descending limb of the antibody concentration curves, starting at a point where the curve assumed an exponential shape (2).

[1]These studies were supported by a grant from the National Science Foundation and by general support from the National Institutes of Health and from the University of Notre Dame.

Results and Discussion

A single dose of BSA injected intravenously into the conventional chicken produces precipitating antibody which reaches a maximum concentration approximately 8 days later. Shortly thereafter, this production terminates and the antibody in the circulation is catabolized at the same rate as the overall gamma globulin fraction, which has a half life of 4.2-4.3 days. In the germfree chicken under these conditions less antibody is formed, but its half value time of 8 days indicates that a prolonged antibody production takes place which partially compensates for this gamma globulin catabolism and results in an extended half value time (Fig. 1, series I) (2).

Treatment of the germfree chicken with a second antigen (HGG) just before the anti-BSA antibody concentration reaches a maximum value reduces the half value time for this antibody to 4.5 days (Fig. 1, series II). This indicates that after HGG treatment the anti-BSA antibody concentration now decreases at a rate comparable to the turnover rate of the main body of the gamma globulin fraction and suggests that little or no new formation of anti-BSA precipitin takes place after the tenth day.

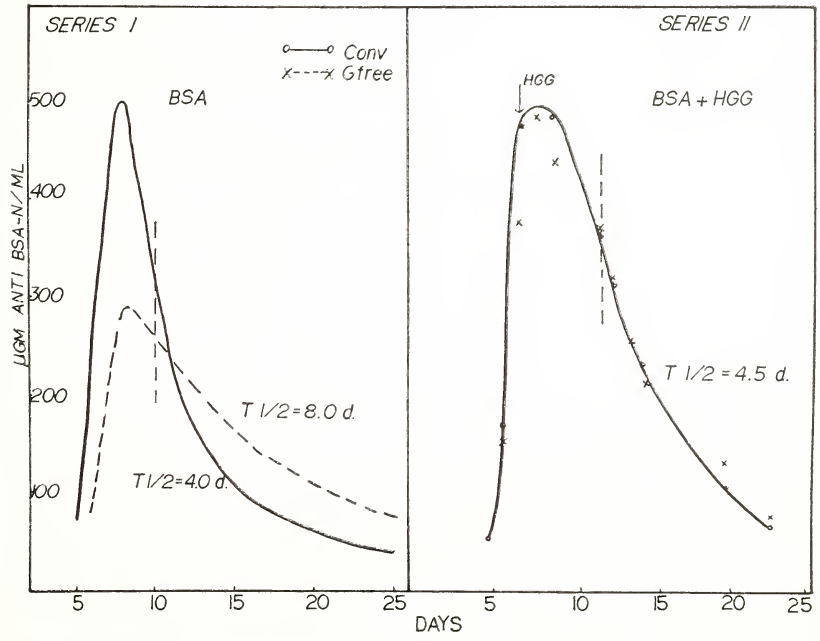


Fig. 1. Anti-BSA precipitins formed in germfree and conventional chickens after a single i. v. dose of BSA (left) and after a dose of BSA, and a dose of HGG administered 7 days later (right).

However, the anti-HGG precipitin response to this second injection again demonstrates the difference in half value time between germfree and conventional birds that was observed in animals which had received a single injection of BSA or HGG (Fig. 2 and Table I). In con-

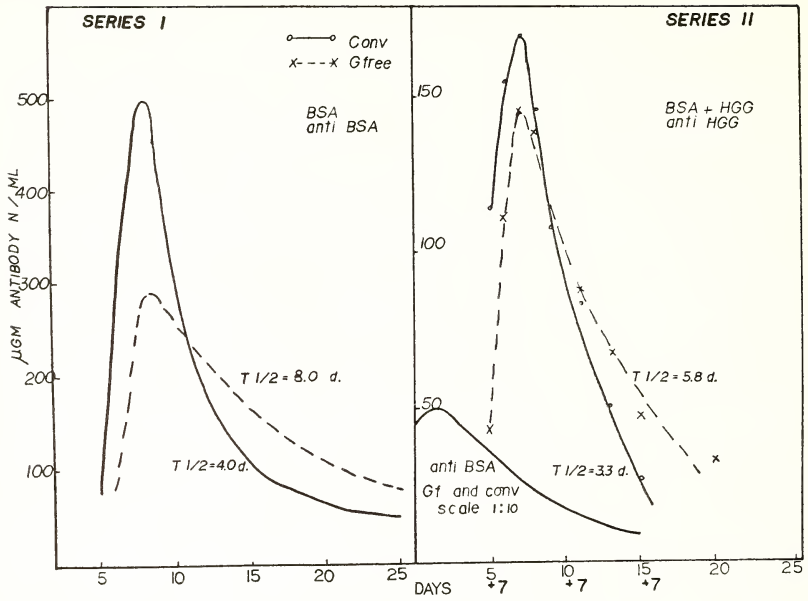


Fig. 2 Precipitin response after a single dose of BSA (left) and after a dose of BSA, and a dose of HGG administered 7 days later (right). Time scale anti-HGG response starts at day of injection of HGG (see text).

ventional chickens the anti-HGG antibody shows a half value time slightly less than the approximate 4 day value established for the half life of chicken gamma globulin. The half value time in germfree birds is 50% higher than the gamma globulin half life and almost twice the half value time found in conventional animals, again indicating a prolonged antibody formation in the absence of other major antigenic stimuli. The data also demonstrates the difference between the anti-BSA and anti-HGG response in general, which seems to be caused by an earlier termination of the major phase of anti-HGG antibody production, resulting in lower maximum concentrations which are reached a day earlier than in the case of the anti-BSA response.

The quantitative aspects of these studies have been brought together in Table I. These data show, that the subsequent administration of the second antigen (HGG) suppresses the extended anti-BSA antibody response in the germfree bird but apparently increases the magnitude of this response. These effects are not seen in the conventional animal. On the other hand, the response to HGG, the second antigen, is definitely depressed in both groups as a result of the earlier administration of BSA.

The data consistently show a difference in half value time between anti-HGG and anti-BSA antibody produced in conventional chickens. Assuming that during the period in which these values were determined no appreciable new formation of precipitating antibody occurs, then this suggests that the half life of anti-HGG antibody is shorter than

TABLE 1

Precipitating antibody in the plasma of germfree and conventional chickens injected i.v. with BSA (40 mg), or with BSA (40 mg) followed 7 days later by HGG (40 mg).

		Max. antibody response μgm AbN/ml		T ½ days		
BSA response		BSA		BSA ± HGG	BSA	BSA ± HGG
Series I	GF	290 ± 29[1] (>10)[2]	hs[3]	——	8.0	——
	Conv.	500 ± 74 (>10)		——	4.0	——
Series II	GF	468 (2)		481 ± 39 (9)	—	4.5
	Conv.	707 (3)		493 ± 61 (10)	4.3	4.5
HGG response						
	HGG			BSA ± HGG	HGG	BSA ± HGG
Series II	GF	258 ± 58 (5)	s	146 ± 19 (10)	5.3	5.4
		279 ± 52 (6)	s	170 ± 28 (9)	3.2	3.2

[1]S.D.M. value.

[2]Number of animals.

[3]Significance of difference; s indicates $P \leq 0.05$; hs indicates $P \leq 0.01$.

that of anti-BSA antibody, and also somewhat shorter than the half life of the total ammonium sulfate precipitated gamma globulin fraction. With the controversy about the nature of the antibody resulting from a primary stimulation in the chicken not yet resolved (5, 6), it is difficult to speculate about the meaning of these differences.

The picture which emerges from these studies is that when major antigenic stimuli are absent, as in the germfree chicken, stimulation with BSA results in a response which continues beyond the eighth day, when maximum titers are reached. The administration of a second unrelated antigen, e.g. HGG, produces an instantaneous increase in the amount of anti-BSA antibody released to the circulation, but the protracted response is suppressed. The second antigen, on the other hand, seemingly finds only part of the potential antibody producing system available. The resulting anti-HGG response in both groups is depressed in comparison to that of animals receiving only a single injection of this antigen. However, the germfree animal demonstrates a prolonged response to this second antigen that is similar to that found after the administration of a single antigen.

Summary

Germfree and conventional chickens were administered two unrelated antigens, BSA and HGG. The second antigen, HGG was given one day before anti-BSA precipitins reached a maximum value. This resulted in a suppression of the extended anti-BSA precipitin formation otherwise observed in germfree chickens. Formation of anti-HGG precipitin was depressed in both experimental groups, but the germfree birds demonstrated a prolonged response to HGG similar to that seen after the administraion of a single antigen.

Literature Cited

1. Thorbecke, G. J., H. A. Gordon, B. S. Wostmann, M. Wagner, and J. A. Reyniers. 1963. J. Infect. Dis. **101**:237.
2. Wostmann, B. S. and G. B. Olson. 1964. J. Immunol. **92**:41.
3. Wostmann, B. S. and H. A. Gordon. 1958. Proc. Soc. Exper. Biol. Md. **97**:832.
4. Preer, J. R., Jr. 1956. J. Immunol. **77**:52.
5. Benedict, A. A., R. T. Hersh, and C. Larson. 1963. J. Immunol. **91**:795.
6. Rosenquist, G. L. and R. V. Gilden. 1963. Biochim. Biophys. Acta **78**:543.

Lymphocytopoiesis and Plasmacytopoiesis in Germfree Mice Stimulated With 7s Human Gamma Globulin[1]

GEORGE B. OLSON and B. S. WOSTMANN, University of Notre Dame

INTRODUCTION

Germfree animals have been described as having a reticulo-endothelial system (RES) of approximately one-half that of their conventional counterparts. This deficiency has been ascribed to smaller lymph nodes (1), fewer or complete absence of secondary nodules and fewer plasma cells (2), reduced serum gamma globulin levels (2), and less circulating antibody (3). Furthermore, it has been suggested that there is a longer latent phase in antibody production in the germfree animals (3). However, even with these deficiencies the germfree animal has been credited with the ability of making a satisfactory immune response to an antigenic stimulation.

To better understand this immune response it was decided to establish (a) the normal quantitative values for lymphocytopoiesis and plasmacyopoiesis in the nonstimulated germfree Swiss-Webster mouse, (b) to determine the quantitative changes in this cellular defense mechanism in response to a single antigenic stimulation of 7s human gamma globulin, (c) to determine the rate of proliferation of the lymphoid tissues in the nonstimulated and stimulated states using autoradiographic methods and tritiated thymidine (TH^3) as the isotopic label for DNA synthesis.

Material and Methods

To establish the differential counts and rate of proliferation of tissue in nonstimulated mice, germfree and conventional mice were injected I. P. with 1 μc TH^3/gm body weight and subsequently sacrificed at 2, 4, 24, and 48 hour time intervals. Samples of the mesenteric and cervical lymph nodes were removed, and teased to single cell suspensions in Earl's solution. The cell suspensions were brushed onto microscope slides, fixed overnight in 1% acid methyl alcohol, and coated with a nuclear emulsion, NTB-2, for autoradiography (4). After exposure times of 21 or 42 days the slides were developed for 2 minutes in Dektol, acid fixed for 4 minutes in Kodak Acid fixer, stained in Giemsa stain at 17° C for 5 minutes (5), and evaluated on the following basis: (1) Cells composing the differential count were classified as blasts, large, medium, and small lymphocytes (LL, ML, and SL), plasmoblasts (PB), immature plasma cells (IMPC), mature plasma cells (MPC), smears and macrophages (6). Counts consisted of 1000 cells. (2) The number of labelled cells of each type was recorded as was the total labelled cells per 1000 cells.

In antigen stimulated animals the antigen was injected I.P. 2 hours after TH^3. Animals were sacrificed starting at 1 day after

[1]This research was supported by the National Science Foundation Grant GB 1105, and by National Institutes of Health Grants AM 00566-12 and GM 17936-02.

TABLE 1
Quantitative Lymphocytopoiesis Values for Mesenteric and Cervical Lymph Nodes of Nonstimulated Germfree and Conventional Mice

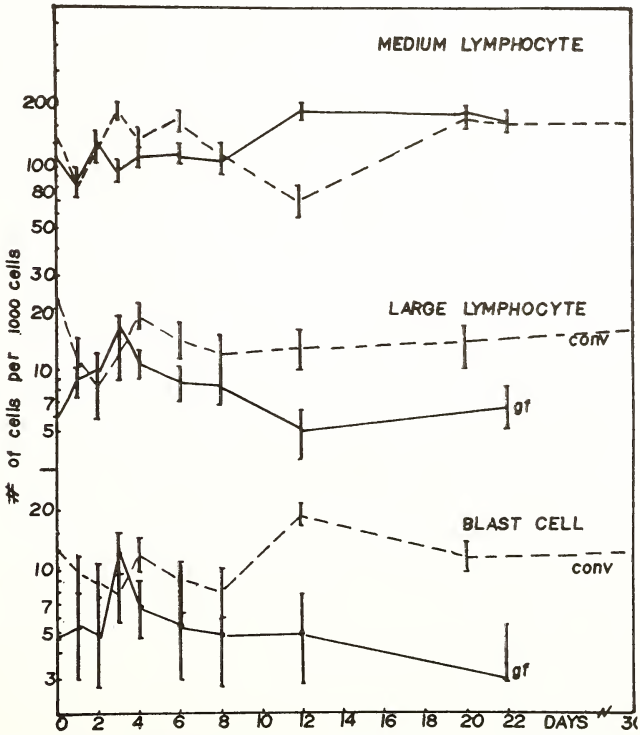
Type Node	Blasts	PB	LL	IMPC	ML	SL	MPC	Smears	Macrophages
Conv.									
Mes. (9)	13 ±2.8	2.9 ±0.4	23.5 ±4.9	6.8 ±1.1	134 ±11.7	708 ±13	1.3 ±0.6	97 ±8.2	12 ±2.9
Cerv. (9)	7 ±1.0	3.5 ±1.2	13 ±2.1	9.6 ±1.2	189 ±15.6	652 ±21	2.8 ±0.4	109 ±10.3	13 ±2.7
Germfree	4.9	0.75	6.1	1.5	114	742	0.5	124	7
Mes. (8)	±0.7	±0.35	±0.8	±0.3	±12	±20	±0.5	±14	±1.2
Cerv. (7)	3 ±0.25	1.3 ±0.3	4.4 ±0.75	4.6 ±0.65	173 ±14.9	670 ±33	1.1 ±1.2	139 ±21	2.4 ±0.6

and at designated times for the next 30 days. The lymph node suspensions were prepared as mentioned previously.

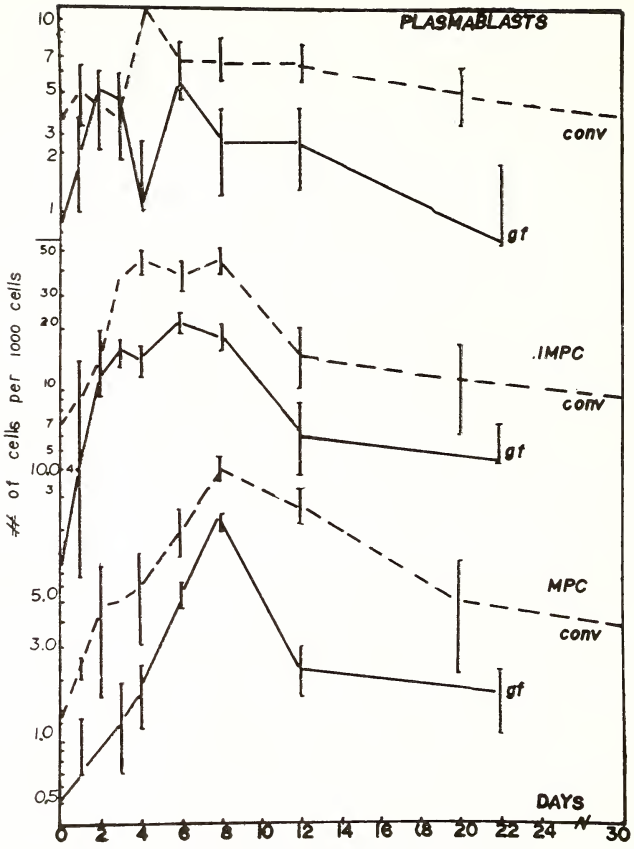
Results and Discussions

Table I shows the differential counts for lymphocytopoiesis of the mesenteric and cervical lymph nodes of nonstimulated germfree and conventional mice. If these cells are classified into two groups called (1) nonprimitive cells and (2) primitive cells based on their apparent ability to differentiate into cells capable of entering into the antibody response (blasts, PB, IMPC, and LL) (6), it is obvious that the germfree animal has one-third the amount of these primitive type cells as compared to the conventional mice. The quantity of these primitive cells in the germfree mouse does not differ between the mesenteric and cervical nodes whereas in the conventional animal the mesenteric nodes contain about 50% more primitive cells than does its cervical lymph node.

There is no significant difference between the number of ML and SL in these two groups, but there is a difference in the distribution of these two cell types in the nodes of these two groups. In both germfree and conventional conditions the cervical node contains more ML (about 18%) compared to 12.4% in the mesenteric node. There is



Graph I. Differential lymphocytopoiesis of mesenteric node of germfree and conventional mice stimulated with 7s human gamma globulin.



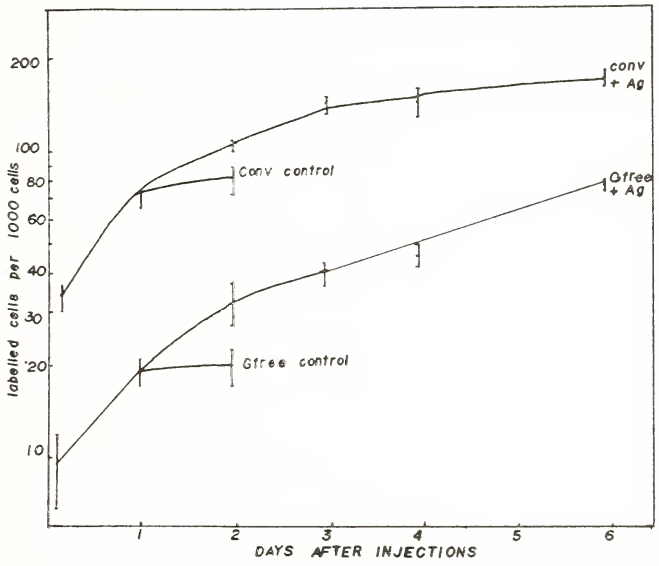
Graph II. Differential plasmacytopoiesis of mesenteric node of gremfree and conventional mice stimulated with 7s human gamma globulin.

approximately a factor 2 difference in the MPC distribution between the germfree and conventional mice. No difference was found in the number of recognizable macrophages between the cervical and mesenteric node of the conventional mice, but the germfree mice showed substantially less.

Following antigenic stimulation the statistical difference in the blasts, plasmablasts, and large lymphocytes of the mesenteric node in the germfree and conventional animals was lost for about an 8 day period (Graph I). This was due to a first day increase in these cell types in the germfree mouse while the conventional animals show a decrease during the first day. During this 8 day time interval the IMPC and MPC depict great proliferation with 7 and 17-fold increases respectively in conventional mice and 15 and 24-fold increases respectively for the germfree mice (Graph II). The peak quantity of these cells appear on the 3rd-4th day for the plasmablasts, the 4th-6th day for IMPC, and the 8th day post antigen injection for MPC. This shift

in cell types as a function of time depicts the maturation of the cells in plasmacytopoiesis. However, even at peak quantities for the IMPC and MPC the conventional mice have nearly two times the quantity of these cells as does the germfree animal. Thirty days after antigen stimulation the cellular components of the mesenteric node have returned to their normal base levels.

The proliferation of lymphoid tissue in the mesenteric node can be determined by the initial uptake of TH^3 in cells and the subsequent increase of TH^3 labelled cells due to cellular division. Graph III depicts three interesting items found in the mesenteric node of the germfree and conventional mice, when comparing the amount of labelled cells per 1000 cells found at various times after TH^3 injection and in the case of stimulated mice, an antigen injection. (1) In a given time period



Graph III. Cellular activity of mesenteric node of germfree and conventional mice stimulated with 7s human gamma globulin.

(2 hours) the conventional mice have a TH^3 uptake about four times greater than the germfree mice. (2) The rate of increase in the labelled cells as a function of time after TH^3 injection shows no difference in the rate of proliferation between these two groups. (3) In the antigen stimulated mice the increase of labelled cells was greater in both groups. A plateau was not reached after 1 day as was observed in the nonstimulated cases, but labelled cells continued to accumulate until about day 6.

One cannot interpret this 2 hour difference in uptake of label to mean a greater proliferation rate for the conventional mice because if this was the case the subsequent increase in labelled cells would be greater in the conventional mice and would be depicted by a line with a greater slope. The generation time of the cell population in nonstimu-

lated and stimulated germfree and conventional mice can be determined using the tritium index method (7), where

$$TH^3 \text{ index} = \frac{\text{number labelled } TH^3 \text{ labelled cells at X time}}{\text{number labelled } TH^3 \text{ labelled cells at 2 hours}}$$

A graphic plot of the index for a given set of data on the ordinate versus the respective time as the abscissus gives a convenient way of determining the amount of time needed for the index to be doubled. This time is considered to be an indication of the generation time (7). Table II shows that upon stimulation with a mild antigen this proliferation time is reduced from approximately 24 hours to 17 or 18 hours in both the germfree and conventional animal.

TABLE 2

Proliferation Time for Nonstimulated and Stimulated Germfree and Conventional Mice (Tritium Index Method)

	Nonstimulated	Stimulated
Germfree	26 hrs.	17 hrs.
Conventional	25 hrs.	18 hrs.

Walburg and Cudkowicy (8) by using whole organ scintillation detection, reported a longer proliferation time for lymphoid tissues in germfree animals. But these observations on the individual cell count suggest that what Walburg and Cudkowicy have reported is actually the difference in uptake of TH^3 label by the lymphoid tissues.

The following hypothesis consisting of two parts is advanced to explain this original difference in labelling. In the first place, the uptake of label is dependent upon cells undergoing DNA synthesis, and it has been reported that primitive type cells have a greater tendency for DNA synthesis than nonprimitive cells (6). Since the lymph node of the conventional animal has three times more primitive cells than its germfree counterpart it may be expected to take up more label in a given time period. Secondly, the germfree animal may have a physiological barrier in its node structure. Perhaps due to its protected environment and limited contact with antigenic stimulation, there is a restriction of blood flow to the lymph nodes, or a restriction of lymph circulation in the various peripheral and medullary sinuses. Consequently, the TH^3 label comes in contact with and is incorporated in the DNA of only those cells in the S phase that are adjacent to the unrestricted sinuses. These two factors would result in a greater uptake of label per unit of time in the conventional animal.

Summary

The quantative determination of lymphoid tissue shows the germfree animal to have about one-third the number of primitive type cells that may enter into an antibody response as compared to its conventional counterpart. Upon antigenic stimulation the amount of plasma cells in the germfree mouse remains approximately one-half that of the conventional animal although there is no difference in the time when these

cells reach their peak concentration. Auto-radiographic studies show there is no difference in the normal proliferation rate of lymphoid tissues of the germfree and conventional mice.

Literature Cited

1. Gordon, H. A., and B. S. Wostmann. 1958. Responses of the animal host to changes in the bacterial environment: Transition of the albino rat from germfree to conventional state. Rec. Prog. in Microbiol. 336-339.
2. Thorbecke, G. J., H. A. Gordon, B. S. Wostmann, M. Wagner, and J. A. Reyniers. 1957. Lymphoid tissue and serum gamma globulin in young germfree chickens. J. Inf. Dis. **101**:237-251.
3. Wostmann, B. S. and G. B. Olson. 1964. Precipitating antibody production in germfree chickens. J. Immunol. **92**: 41-48.
4. Kopriwa, B. M., and C. P. Leblond. 1962. Improvements in the coating technique of radioautography. J. Histochem. and Cytochem. **10**:269-284.
5. Gude, W. D., A. C. Upton and T. T. Odell. 1955. Giemsa staining of autoradiograms prepared with stripping film. Stain Tec. **30**:161-62.
6. Nossal, G. J. V., and D. Makela. 1962. Autoradiographic studies on the immune response. I. The kinetics of plasma cell proliferation. J. Exp. Med. **115**:209-230.
7. Capalbo, E. E., T. Makinodan, and W. D. Gude. 1962. Fate of H^3-thymidine-labelled spleen cells in vitro cultures during secondary antibody response. J. Immunol. **89**:1-7.
8. Walburg, H. E., and G. Cudkowicy. 1963. Studies on cellular turnover in gnotobiotic mice by use of I^{131}-iododeoxyuridine. Abstract. Symposium on recent advances in germ-free animal experimentation 1959-62. Am. Inst. Biol. Sci.

Inhibitory Action of Statolon Against Polyoma Virus

H. M. Powell, Indiana University Medical Center

Rowe and collaborators (1) have shown that although cytopathic effect (CPE) on mouse embryo tissue culture, hemagglutinin inhibition (HI) antibody produced in suckling mice, and tumors produced in suckling hamsters may serve as indicators of the titer of mouse polyoma virus, the first two of these are subject to less variability than the latter in testing this virus. We have chosen tests of CPE of polyoma virus on mouse embryo tissue culture for use in examining the effects of statolon on this rodent virus, and, although in vivo work is now indicated and still needs to be done, this paper shows statolon has considerable inhibitory action against this virus. The experimental results reported here are part of a larger study of the extension of the spectrum of statolon and this will be reported in detail later.

Materials and Methods

Whole mouse embryo trypinized tissue culture in Eagle's basal medium with five per cent inactivated horse serum plus antibiotics was obtained from Microbiological Associates, Polyoma virus VR 252 was obtained from the American Type Culture Collection. Statolon lot 209-617B-242-1 was furnished by Lilly Research Laboratories. Tissue culture tubes when received were subjected to two addtional days of incubation at 37°C for a more complete monolayer to form. At this time the medium was drained off and new medium of the same kind added. Then 0.1 ml of a series of doubling dilutions of statolon made in basal medium as indicated in Table 1 was added to all tubes except virus controls. After twenty-four hours additional incubation of the tissue cultures in the presence of statolon on roller drums, all fluid was again drained off, new fluid was added, then a series of 0.1 ml doses of various decimal dilutions of polyoma virus were added using three tubes of tissue culture per virus dilution and the tubes reincubated. Statolon toxicity tubes had no virus added. Medium changes were made after intervals of 4, 4, 6, and 7 days. Tissue culture tubes were examined at the six times indicated in Table 1 for evidence of damage by virus or drugs and results are as indicated from — to 4+. Since this test included three variables, i.e., statolon dilutions, virus dilutions, and different incubation periods, tabulation of direct CPE readings appeared most feasible for indicating results.

Results

It is apparent from Table 1 that dilutions of statolon of 1-400 to 1-12,800 show substantial inhibition of polyoma virus and practically no toxicity with the exception of one or two tubes on 1-6,-400 statolon. These may have been "cross infections" from virus tubes which at this time had been opened several times. Other dilutions of statolon showing no toxicity and decreasing inhibition, but

[1]Aided by a grant from the James Whitcomb Riley Memorial Asssociation.

TABLE 1

Statolon	Virus	8 days	10 days	14 days	18 days	21 days	25 days
1-400	10^{-2}	+ + +	++ + +	+++ +++ +++	+++ +++ +++	+++ +++ +++	++++ +++ ++++
”	10^{-3}	+ + +	+ − +	++ ++ +	+++ +++ ++	+++ +++ +++	+++ +++ +++
”	10^{-4}	− − +	+ + +	+ + +++	+ + ++	+ + ++	+ + +++
”	10^{-5}	+ − −	+ + −	++ + −	++ + −	++ + −	++ + −
”	0	− − −	+ − −	+ − −	+ − −	+ − −	+ − −
1-800	10^{-2}	− − −	+ + +	++ ++ ++	+++ +++ +++	+++ +++ +++	+++ +++ +++
”	10^{-3}	− − −	+ − +	+ + +	++ ++ ++	++ ++ ++	++ ++ ++
”	10^{-4}	− − −	− − −	− − +	− − −	− − −	− − +
”	10^{-5}	− − −	− − −	− − −	− − −	− − −	− − −
”	0	− − −	− − −	− − −	− − −	− − −	− − −
1-1,600	10^{2}	− − −	+ − +	++ +++ +++	+++ +++ +++	+++ +++ ++++	++++ ++++ ++++
”	10^{-3}	− − −	− + +	− + +	++ ++ +++	+++ +++ +++	+++ +++ +++
”	10^{-4}	− − −	− − −	− − −	++ ++ +	+++ +++ ++	+++ +++ ++
”	10^{-5}	− − −	− − −	− − −	− − −	− − −	− − −
”	0	− − −	− − −	− − −	− − −	− − −	− − −
1-3,200	10^{2}	− − −	++ ++ ++	+++ +++ +++	+++ +++ +++	++++ ++++ ++++	++++ ++++ ++++
”	10^{-3}	− + −	− + +	+ ++ ++	++ +++ +++	+++ ++++ ++++	++++ ++++ ++++
”	10^{-4}	− − −	− − −	− − −	+ − +	+++ + ++	+++ ++ +++
”	10^{-5}	− − −	− − −	− − −	− − −	− − −	− − −
”	0	− − −	− − −	− − −	− − −	− − −	− − −
1-6,400	10^{2}	+ − −	++ ++ ++	+++ +++ +++	+++ +++ +++	+++ ++++ +++	++++ ++++ ++++
”	10^{-3}	− − −	+ + −	++ ++ ++	+++ +++ +++	+++ ++++ ++++	++++ ++++ ++++
”	10^{-4}	− − −	− − −	− − +	++ + +++	++ ++ ++++	+++ ++ ++++
”	10^{-5}	− − −	− − −	− − +	− + −	− − +	− − +
”	0	− − −	− − −	− + +	− + −	− ++ −	− +++ −
1,12,800	10^{2}	− ++ ++	− ++ ++	+++ +++ +++	+++ +++ +++	++++ ++++ ++++	++++ ++++ ++++
”	10^{-3}	− − −	+ + +	++ ++ ++	+++ +++ +++	++++ ++++ ++++	++++ ++++ ++++
”	10^{-4}	− − −	+ − +	++ − ++	++ ++ ++	+++ +++ +++	++++ ++++ ++++
”	10^{-5}	− − −	− − −	− − −	+ ++ +	++ +++ ++	+++ +++ +++
”	0	− − −	− − −	− − −	− − −	− − −	− − −
0	10^{2}	++ ++ ++	+++ +++ +++	++++ ++++ +++	++++ ++++ +++	++++ ++++ +++	++++ ++++ ++++
”	10^{-3}	+ + +	+++ +++ ++++	++++ ++++ ++++	++++ ++++ ++++	++++ ++++ ++++	++++ ++++ ++++
”	10^{-4}	+ + −	++ ++ ++	+++ +++ +++	++++ ++++ ++++	++++ ++++ ++++	++++ ++++ ++++
”	10^{-5}	− − −	+ − −	++++ − +	++++ ++ +++	++++ +++ +++	++++ ++++ +++
”	0	− − −	− − −	− − −	− − −	− − −	− − −

not recorded in this table, were 1-25,600, 1-102,400, and 1-204,800. It is apparent that inhibitory action of statolon against the virus in maximal at a drug dilution of 1-800 and this become gradually less as the concentration of statolon decreases. It is also apparent that at any given concentration of drug, the weaker virus dilutions are more easily inhibited than the stronger dilutions. Comparison of results of drug action against 10^{-2} and 10^{-5} dilutions of virus shows a maximum of 1000 fold as much virus may be inhibited under different conditions, and also the degree of inhibition noted at a shorter period of incubation may decrease with further incubation generally involving changes of media.

Discussion

Kleinschmidt and Probst (2) have partially characterized statolon as a macromolecular polyanionic polysaccharide composed of galacturonic acid, galactose, galactosamine, glucose, arabinose, xylose, and rhamnose. They did not crystallize this compound. With the exception of the report of Johnson and Baker (3) who reported this drug, known first as 8450, as effective against Rous sarcoma virus, most viruses within the drug's spectrum of activity are small neurotropic viruses viz. Semliki Forest, MM, polio, and Russian Spring Summer virus. Exceptions have been several small viruses involved to some extent in the cause of some common colds, i.e., the HGP (of Andrewes), JH or 2060, and Coe (Coxsackie A21). In some instances of evidence of activity, tissue culture alone has been used; in others, animals alone have been used; and in some cases activity has been shown in both tissue culture and animals. In all cases, pretreatmet of tissue culture or animals with statolon (later followed by virus) has shown the greatest extent of antiviral action. In a very few instances a very slight degree of effective post-infection chemotherapy can be shown. In most, if not all tissue culture experiments, statolon can be removed from once treated tissue before virus is added, and full anti-viral chemoprophylaxis results. The mechanism of antiviral action certainly is not contact, but rather prevention or blocking (for a time) of virus penetration into otherwise susceptible cells. Location of the precise site and time of action has not been determined. There is nearly always considerable margin of safety between toxic and effective antiviral doses of statolon in both tissue culture and mouse experiments. Whether statolon may have any practicality in treating human infections is not known at present. It seems any possibility of trial usage would depend on infections where direct application of drug is possible.

Summary

Statolon has been found to have demonstrable inhibitory action against polyoma virus as grown and tested on whole mouse embryo tissue culture. Considerable leeway is evident between toxic dose of this drug and effective virus inhibitory doses. Polyoma virus is the second tumor-producing virus to be included in the spectrum of activity of statolon.

Literature Cited

1. Rowe, W. P., J. W. Hartley, J. D. Estes and R. J. Huebner. 1959. Studies of Mouse Agent. Antibiot. and Chemo. 12:298-309
2. Kleinschmidt, W. J., and G. W. Probst. 1962. The Nature of Statolon, an Antiviral Agent.
3. Johnson, I. S., and L. A. Baker. 1958. The Utility of Rous Sarcoma Virus for Detection of Antiviral Activity. Antibiot. and Chem. 8:113-121.

Mouse Tests of Poliomyelitis Vaccine

H. M. Powell, Indiana University Medical Center

During the past, as a substitute for costly monkey tests, we have tested vairous lots of inactivated polio vaccine in mice for antigenicity. This has been done by injecting groups of mice each with a single dose of vaccine intraperitoneally. Three days later some of these mice are challenged intravenously with Type 2 virus, and four days later other groups are challenged intraspinally with Type 1 and 3 virus respectively. Proper doses of particular strains of virus injected by the routes indicated are necessary for early challenge (1,2). Control mice included suitable groups injected with a standard reference vaccine, and other groups to check virulence of the challenge viruses. Optimum dose of each challenge virus was an amount that would paralyze eight to ten of ten normal control mice and approximately two to four of ten additional controls given one tenth of such challenge. Generally three, ten-fold dilutions of vaccine have been tested, and groups of twenty mice used. These mice have been of about twelve to fourteen grams weight since the challenge viruses we used were best adapted to the smaller mice. Significant antibody titers are not present in these mice at the time of challenge. In his original work with Type 2 components tests, Krech (3) used CFW mice; however, we obtained these mice only occasionally, and generally used various other breeder's mice. These mouse tests are terminated and final results read seven days after challenge.

In general, it has appeared that through use of mouse tests we could distinguish three grades of vaccines, namely (a) good, (b) fair, and (c) ineffective. Only those vaccines purposely heated at elevated temperatures (2) and those more or less drastically treated (4) have been devoid of potency in our mouse tests. Since we used ordinary stock mice, it appeared of little use to try to determine earlier if the test could be rendered more quantitative as Krech has indicated for the Type 2 component.

Many experiments have been done varying the number of dilutions of vaccine used, the number of mice used per dilution of vaccine, and also the kind of mice including local stock mice and small numbers of CFW mice. As a temporary standard reference vaccine we used lot 649332. This lot and the three challenge viruses have already been described (1,2). Vaccine 2769 is a representative trivalent lot made of Mahoney, MEF 1, and Saukette strains currently used in the Salk Vaccine. Comparative tests were first done using these vaccine each in dilutions of 1:5, 1:50, 1:500 and twenty CFW mice per dilution of vaccine for each of the three challenge types. Previous tests mainly utilized five, five-fold dilutions of vaccine and ten mice per dilution per type.

The results shown in Table 1 indicated that ED_{50} values of vaccine 2769 of 24; 61; 24; (Types 1, 2, and 3, respectively) are comparable typewise to ED_{50} values of vaccine 649332 of 71; 83; and 26. These

TABLE 1

Polio Vaccine Mouse Tests Using Three Dilutions of Vaccine and Twenty CFW Mice Per Dilution. Mice Living and OK at Seven Days/Mice Used.

Vaccine Lot	0.5 ml. Vaccine Dilution i.p.	Type 1 Intraspinally OK/Used	Type 1 ED_{50}	Type 1 %S	Type 2 Intravenously OK/Used	Type 2 ED_{50}	Type 2 %S	Type 3 Intraspinally OK/Used	Type 3 ED_{50}	Type 3 %S
2769	1:5	11/20			13/20			11/20		
	1:50	9/20			11/20			9/20		
	1:500	4/20	24	40	7/20	61	51	4/20	24	40
649332	1:5	12/20			12/20			12/20		
	1:50	13/20			13/20			7/20		
	1:500	6/20	71	51	8/20	83	55	7/80	26	43
1.0 Challenge dose virus		0/10			0/10			1/10		
0.1 Challenge dose virus		4/10			7/10			7/10		

Legend: Under ED_{50} is recorded the reciprocal of the vaccine dilution completed by the method of Reed and Muench[5] to save half the mice. %S indicates the per cent surviving and OK of all mice used.

figures indicate that while 2769 is lower than 649332 in the Type 1 component, the two are about equal in potency of Type 2 and 3 components. Corresponding per cent of total mouse survival of 2769 of 40; 51; 40 may be compared to 649332 showings of 51; 55; 43. Both ED_{50} values and total mouse survival percentages indicate that vaccine 2769 may be classed as fairly good. Mouse survival percentages seem to indicate closer similarities in potency than do ED_{50} values. It appears that the use of three, ten-fold dilutions of vaccine (1:5, 1:50, 1:500) and twenty mice per dilution per type may be preferable to five, five-fold dilutions and ten mice per dilution per type as previously used.

From data in such comparative potency tests using control vaccine, one may assign as potency factors of the three component types of a given batch of vaccine the figures obtained by dividing the ED_{50} values of the test vaccine by the corresponding ED_{50} values of the control vaccine. Table 2 shows, in the first horizontal line, the potency factors of vaccine 2769 as derived from the data in Table 1 in which

TABLE 2

Potency of Polio Vaccine 2769 in Relation to Standard Vaccine 649332

Vaccine 2769	Potency Against Types:		
	(1)	(2)	(3)
In CFW Mice	0.33	0.73	0.92
In Harlan Mice	0.64	0.41	0.5

Potency is ED_{50} of test vaccine/ED_{50} of Standard Vaccine.

CFW mice were used. In the second horizontal line of Table 2 are shown potency factors of vaccine 2769 derived from a similar test in which local Harlan mice were used, and details of which need not be included here. The variation in response as shown in Table 2 is about two to one. This appears within expectation for biological tests of this order, and corresponds to a "one tube" variation in certain serological tests. It may be that the three components of the vaccine have independent and variable antigenicity in different strains of mice. Whether any natural or latent infection of mice conditions them to react better or worse in a type selective way to polio vaccine is not known. In most mouse tests we have noted better antigenicity of the Type 2 component than Type 1 which in turn is better than Type 3. The Type 2 component is more stable to heat than the Type 1 component as based on mouse tests (2) and may be a better antigen for this or some other reason.

Further work is being done as time allows to determine the degree of accuracy of the mouse test when different coded vaccines are used as unknowns. These results may be compared to monkey potency test results which are based on antibody titers instead of challenge with live virus.

Mouse tests of polio vaccine may be done in eleven days, are economical, and necessitate practically no interpretation. Immunity is indicated by freedom from paralysis, in addition to survival of mice

against live virus challenge. Vaccines may be graded roughly as "good", "fair", or "ineffective". Mouse tests done under these conditions are not adapted to measurement of virus neutralizing antibody which at this time is likely sessile.

Literature Cited

1. Powell, H. M. and C. G. Culbertson. 1955. Mouse Immunity Tests of Trivalent Poliomyelitis Vaccine. Proc. Soc. Exp. Biol. and Med. **88**:563-564.
2. ..... 1955. Short Term Heat Stability of Poliomyelitis Vaccine. Proc. Soc. Exp. Biol. and Med. **89**:490-492.
3. Krech, U. 1955. Development of Immunity in Mice After Vaccination with Inactivated Poliomyelitis Virus. Jour. Immunol. **74**:117-119.
4. Davisson, E. O., H. M. Powell, J. O. MacFarlane, R. Hodgson, R. L. Stone and C. G. Culbertson 1956. The Preservation of Poliomyelitis Vaccine With Stabilized Merthiolate. Jour. Lab. and Clin. Med. **47**:8-19
5. Reed, L. J., and H. Muench. 1938. A Simple Method of Estimating Fifty Per Cent End Points. Amer. Jour. Hyg. **27**:493.

Identification and Physiological Studies of Soil Bacteria Causing Fungistasis[1]

Paul L. Smith and Ralph J. Green, Jr.
Purdue University

Introduction

Most fungi in soil are represented only by inactive propagules (12). Germination is not limited by lack of nutrients or other essential growth factors but by inhibitors. Dobbs and Hinson (5) described the phenomenon of fungistasis in soil and demonstrated that spores of most fungi fail to germinate because of this principle. Park (9), Jackson (6), and Lingappa and Lockwood (7) have confirmed this phenomenon. Jackson (6) suggested that fungi could be grouped into 3 categories, depending upon sensitivity, to the fungistatic principle. These include a) significant reduction in spore germination, b) spores unaffected and c) spore germination stimulated.

The fungistatic principle is assumed to be of biotic origin, since heat treatment, prolonged drying, treatment with organic solvents and elution with citrate buffer reduced or destroyed activity (5). Lingappa and Lockwood (7) showed that pH, redox potential, osmotic conditions and volatile substances from soil were not responsible for fungstasis.

The fungistatic principle has not been separated from soil. The failure of spores to germinate may be due either to the presence of some inhibitory factor or the absence of essential growth substance (2). Lockwood (8) found that certain *Streptomyces* spp. restored activity to sterile soil and suggested antibiotics may be involved but Brian (2) considered antibiotics to be significant only if soil was heavily enriched with organic matter. Dobbs and Hinson (5) found that the fungistatic effect could be overcome by the addition of glucose to soil but Chinn and Ledingham (3) found pure glucose ineffective. Enrichment with crude organic matter such as soybean meal reduced fungistasis, however.

Although it is assumed that the fungistatic principle is of biotic origin, little is known concerning which components of the soil microflora or fauna are responsible or the ecologic or physiologic conditions necessary for production of the principle.

The objectives of this research were to:

1) Isolate representative genera of bacteria and antinomycetes from soil and develop methods to assay for fungistatic activity in a cell-free medium and,

[1]Contribution from Purdue University, Agricultural Experiment Station. Journal Paper 2456.

2) To consider the influence of culture medium, cell age, population and metabolic inhibitors on production of the fungistatic principle.

Materials and Methods

The bacteria and actinomycetes used were isolated from soil and characterized by the conventional procedures. Some representative genera were from stock cultures.

Three different methods were used to assay for fungistatic activity *in vitro*. The test fungi were *Trichoderma viride* Pers. ex. Fries and *Pestalotia macrotricha* de Not. Conidial suspensions from 6-9 day old cultures were used in all tests with the criterion for fungistatic activity being the reduction in spore germination when compared to controls. The bacteria and actinomycetes were grown in shake culture in modified nutrient broth-yeast extract medium. Where they were incorporated in water agar, the agar was washed to remove any traces of nutrients.

Method 1. The bacteria were separated from the growth medium by filtration through a sterilized vacuum-type millipore apparatus. The pad (pore size 4.45u) and bacteria were washed with 200 ml of sterile deionized water to remove nutrients. The pad was then inverted in a sterile petri dish, and 2 discs (12 mm diam.) of sterile water agar were placed on the opposite side of the pad. Since the bacteria were separated from the test fungus, the active principle had to diffuse through the millipore pad. A drop of conidial suspension of *T. viride* was placed on each disc and incubated 24 hours as 26°C in a humidity chamber.

Method 2. The bacteria were separated from the medium at 7000 G for 5 min in a Servall centrifuge. The pellets were washed 3 times, using centrifugation and resuspension of cells, to remove nutrients. To assure uniform germination of the condiospores, the pH of the bacterial pellet was adjusted to 5.7-6.5 with phosphate buffer. An 8.5 ml aliquot of this cell system was added to 4 ml of cooled, 2X water agar. After the agar solidified, conidia of *T. viride* were spotted in 4 places, and the plates were incubated at 26° for 24 hrs. Agar blocks were cut from the plates after 24 hr and spore germination determined as in Method 1.

Method 3. The bacteria were not separated from the growth medium prior to testing. Ten 60 x 25 mm pads of Whatman #1 filter paper were stacked in a section of a deep (23 mm) petri dish along with a flat bottom crucible. After sterilization, 1 ml of water was added to the crucible to maintain humidity for spore germination. The bacterial suspension was harvested, pH adjusted to 5.7-6.5 and 5 ml used to saturate the filter paper pads. Two sterile water agar blocks (10 mm x 10 mm) were placed on the saturated filter paper stack and 1 drop of a conidial suspension of *T. viride* was pipetted onto each block. The plates were incubated for 24 hr and percent germination determined as in Method 1.

Representative genera of the bacteria and actinomycetes were grown on 3 media to determine the effect of medium on fungistatic activity *in vitro*. The 3 media used were glucose-yeast extract (GYE), glucose-peptone (GP) and Medium A, a modification of GP.

Glucose Yeast Extract Broth (GYE)

Glucose	2.00 gm	NH_2NO_3	0.20 gm
Yeast extract	0.20 gm	$MgSO_4$	0.20 gm
Peptone	0.07 gm	$FeCl_3$	0.001 gm
Beef extract	0.04 gm	$CaCl_2$	0.010 gm
K_2HPO_4	0.40 gm	A to Z solution	1.0 ml
KH_2PO_4	0.40 gm	H_2O	1.01

Glucose Peptone Broth (GP)

Glucose	5.0 gm
Peptone	5.0 gm
DL Methionine	0.1 gm
H_2O	1.01

Medium A

Glucose	10.0 gm
Peptone	1.25 gm
Beef extract	0.75 gm
NH_4NO_3	0.50 gm
K_2HPO_4	0.25 bm
KH_2PO_4	0.75 gm
$MgSO_4$	0.02 gm
$FeCl_3$	0.001 gm
H_2O	1.01

The bacteria were grown 4 days in the 3 media and a comparison of fungistatic activity determined, using method 2.

The genera used in the study of the effect of age upon production of the fungistatic principle were grown 1 and 8 days in shake culture to obtain cells in the logarithmic stage of growth and as resting cells. The cells were harvested after the predetermined incubation period and tested for fungistatic activity, using Method 2.

In the population density experiment, the lowest population of bacteria/ml necessary to cause total inhibition of spore germination was determined. The bacteria were washed 3 times, using centrifugation and resuspension. An aliquot of the washed bacteria was added to a Petroff-Hausser counting chamber with a Pasteur pipette to estimate the number of bacteria per ml. Serial dilutions of 10^9 to 10 cells/ml were made and an 8.5 aliquot of each population was drawn and tested for activity, as described in Method 2.

The effect of temperature on production of the fungistatic principle by selected bacteria was limited to the range at which 80% spore germination of the test fungi occurred as well as the range of growth of the bacteria. Temperature range for germination of the conidiospores of the 2 test fungi was determined by incubation of spores at 4° to 28°C at 4°C intervals. The bacteria were prepared as outlined in Method 2. The predetermined minimal temperature for 80% germination of *T. viride* and *P. macrotricha* was 16°C and 12°C, respectively. The test plates were incubated at 4°C below the minimum for each test fungus, at the minimum temperature and at 26°C.

The metabolic inhibitors NaN_3 and KCN were used to determine if the biosynthesis of the fungistatic principle was dependent on aerobic respiration. By this means some indication of the nature of the principle might be learned. Washed, 8-day-old cells of species of selected genera of bacteria were suspended in concentrations of 1×10^{-4} to 1×10^{-6} M of the metabolic inhibitors and incorporated into water agar. The dosages were below the levels to which the fungi were sensitive. After incorporation of the bacteria and inhibitors in

water agar, the test conidia were placed on the agar and the assay for fungistatic activity carried out by Method 2.

Results

The genera of bacteria and actinomycetes from soil and selected from stock culture that produce the fungistasis are given in Table 1. In most cases, the same genera occurred in all 3 soils. If a genus taken from each soil produced nearly the same degree of fungistasis, only 1 was included in the later experiments. The genus *Pseudomonas* was in every sample and consistently produced fungistasis. Therefore, it is referred to as *Pseudomonas* spp. If isolates of a genus from different soils or the same soil produced varying degrees of fungistasis, the identity of the isolate was maintained, as *Acromobachter* C14, *Achromobachter* F99, etc.

TABLE 1

The Genera of Bacteria and Actinomycetes from Soil that Produced Fungistasis

Chalmers Silty Clay Loam	Soil of Unknown Origin	Warsaw Loam
Achromobacter C14	*Achromobacter* F99	*Arthrobacter*
Alcaligenes	*Achromobacter* ET	*Achrobacter*
Arthrobacter CA	*Arthrobacter* E2	*Brevibacterium* W10
Pseudomonas	*Bacillus* FZ	*Bacillus*
Micrococcus CQ	*Brevibacterium* ESI	*Rhizobium*
Sarcina C17	*Micrococcus* N2	*Nocardia*
Bacillus	*Nocardia* UO	*Protaminobacter*
Brevibacterium	*Streptomyces*	*Pseudomonas*
Streptomyces	*Arthrobacter* W4	*Micrococcus*
Nocardia CO	*Pseudomonas*	
	Sarcina FS	

The 3 methods used to determine fungistatic activity, **in vitro**, gave comparable results. Method 2 was used throughout these experiments because of its simplicity and ease of preparation.

The influence of the cultural medium on the production of the fungistatic principle by bacteria is given in Table 2.

In some cases, the medium apparently had no effect on production of the fungistatic principle. For example, *Pseudomonas*, *Brevibacterium* ESI, *Arthrobacter* ES2 and *B. subtilis* completely inhibited spore germination regardless of the medium. *Arthrobacter* CA inhibited spore germination when grown on glucose peptone broth and glucose yeast extract but was less active on Medium A. *Rhizobium* spp. and *Sarcina* C17 produced similar results. *Nocardia* spp. and *Proteus vulgaris* do not produce a strong fungistatic effect, but the activity was similar on the 3 media.

In the age studies it was desirable to determine if the production of the fungistatic principle occurred in the logarithmic phase of bacterial growth and if the principle was maintained in resting (8-day-old) cells. Table 3 presents the results.

Most of the isolates, for example, *Pseudomonas* spp., *Nocardia* spp., *Sarcina* FS, *Achromobacter* F99, *Alcaligenes* spp., *Erwinia* spp., *Protam-*

TABLE 2
Influence of Culture Medium on the Production of the Fungistatic Principle

Source	Percent Germination					
	Medium A Broth		Glucose Peptone Broth		Glucose Extract Broth	Yeast
	1[a]	2[b]	1	2	1	2
Arthrobacter CA	48[c]	57	0	0	0	0
Bacillus FL-Z	0	0	5	0	0	0
Nocardia UO	20	41	31	48	29	55
Arthrobacter W4	0	0	0	21	0	1
Proteus vulgaris	23	48	28	59	27	43
Micrococcus N2	0	0	0	9	0	0
Rhizobium spp.	55	77	0	0	0	0
Sarcina C17	42	15	5	3	0	0
Brevibacterium ESI	0	0	0	0	0	0
Pseudomonas spp.	0	0	0	0	0	0
Arthrobacter ES-2	0	0	0	0	0	0
Bacillus subtilis	2	4	0	0	0	0

[a]Conidia of Pestalotia macrotricha used in assay
[b]Conidia of Trichoderma viride used in assay
[c]Average of 2 replications

TABLE 3
The Influence of Age of Bacterial Cells Upon Production of the Fungiastic Principle

Microorganism	Percent Germination			
	P. macrotricha	T. viride	P. macrotricha	T. viride
	1-day-old cells		8-day-old cells	
Brevibacterium W2	68	86	19	93
Arthrobacter ES2	0	20	0	0
Pseudomonas spp.	0	0	0	0
Nocardia CQ	0	0	0	0
Sarcina FS	0	0	0	0
Achromobacter F99	0	0	0	0
Alcaligenes spp.	1	2	0	0
Erwinia spp.	2	5	0	0
Achromobacter 14C	57	0	43	0
Arthrobacter WL4Y	15	48	0	68
Micrococcus CQ	10	74	18	86
Proteminobacter	0	0	0	0
Streptomyces	0	0	0	0

inobacter spp. and *Streptomyces* spp. inhibited germination of conidia of the test fungus after growth for 1 day and the 8 day-old cells were also fungistatic. *Brevibacterium* W2 was slightly inhibitory to *P. macrotricha* after 1 day but increased in fungistatic activity after 8 days. There was no change in the effect with *T. viride*. *Arthrobacter* W4 increased in its fungistatic activity in the 8-day-old cells toward *T. viride*, but decreased in the degree of fungistasis toward *P. macrotricha* in the resting cells.

The cell population necessary to completely inhibit spore germination

of the test fungi was 10^9 cells/ml. The population density of the bacteria did not affect spore germination until concentrations of 10^4 to 10^8 cells/ml were achieved. At a population of 10^7 cells/ml, *Arthrobacter* CA and *Brevibacterium* W10 were fungistatic to *T. viride; Sarcina* FS was fungistatic to *P. macrotricha;* and *Pseudomonas* spp. was totally fungistatic to spores of both test fungi. *Arthrobacter* CA, *protaminobacter*, *Brevibacterium* W10, and *Achromobacter* F99 were totally fungistatic to the test fungi at a poplation of 10^8 cells/ml. When the population had reached 10^9 cells/ml, the bacteria except *Rhizobium* spp. were fungistatic to the test fungi. *Rhizobium* was completely fungistatic to *T. viride* at 10^9 cells/ml, but it was not fungistatic toward *P. macrotricha* at any concentration.

Table 4 presents the results of the influence of temperature upon the production of the fungistatic principle.

TABLE 4
Influence of Temperature on the Production of the Fungistatic Principle

Microorganism	Percent Germination[a]					
	P. macrotricha			T. viride		
	8°C	1212°C	26°C	8°C	1212°C	26°C
Pseudomonas spp.	0[a]	0	0	0	0	0
P. vulgaris	0	66	27	2	39	43
Arthrobacter W4	0	0	0	0	0	0
Achromobacter EST	0	6	68	4	40	82
Nocardia CO	0	27	0	0	17	0
Bacillus spp.	0	18	0	0	30	0
Micrococcus NL2	0	0	0	0	34	0
Brevibacterium ESI	0	20	0	0	70	0
Rhizobium spp.	0	18	90	13	57	0
Sarcina FS	0	0	0	0	91	0
Achromobacter F99	0	0	0	0	5	0
E. coli K12B	0	8	0	10	37	0

[a]Average of 3 replications

Preliminary experiments showed that the lowest temperature which allowed 80% germination of the spores of *T. viride* and *P. macrotricha* was 16°C and 12°C, respectively. The plates of the test bacteria spotted with conidia of *P. macrotricha* were incubated at 8°C, 12°C and 26° C and the plates spotted with conidia of *T. viride* at 12°C, 16°C, and 26°C.

The 16°C temperature altered the fungistasis of *Sarcina* FW, *Brevibacterium* ESI, *Micrococcus* N2, *Rhizobium* spp., *Nocardia* spp., *Bacillus* spp., and *E. coli* toward *T. viride.* Except for *Brevibacterium* EST, and *Nocardia* spp., the fungistatic activity of these bacteria toward *P. macrotricha* was not affected by the low temperature (16°C). *Rhizobium* spp., which was not fungistatic to *P. macrotricha* at room temperature (22-24°C), was inhibitory at 12°C. *Achromobacter* EST was not fungistatic at 26°C but was inhibitory to the spores at the low temperatures.

The results of studies using selected metabolic inhibitors to alter production of the fungistatic principle are given in Table 5. The figures

represent the percent germination of conidia of *T. viride* using KCN and NaN_3 as the inhibitors.

TABLE 5
Effect of Metabolic Inhibitors on the Production of the Fungistatic Principle by Selected Genera of Bacteria

	Percent Germination					
	NAN_3			KCN		
	10^{-4}M	10^{-5}M	10^{6}M	10^{-4}M	10^{-5}M	10^{6}M
Achromobacter F99	81[b]	10	3	11	2	4
Rhizobium spp.						
Pseudomenas spp.	87	42	9	7	1	3
Micrococcus N2	0	0	0	0	0	0
Achromobacter ET	64	30	1	20	2	0
Pseudomonas spp.	0	0	0	0	0	0
Bacillus FZ	2	2	0	0	0	0
Control	80	80	95	95	90	87

[a]Conidia of Trichoderma viride used as test fungus
[b]Results of 2 replications

Concentrations of 1 x 10^{-4} M NaN_3 and 1 x 10^{-6} M KCN, 80% spore germination or greater occurred.

The fungistatic activity of *Achromobacter* F99, *Achromobacter* ET, and *Rhizobium* spp. was markedly reduced after the addition of 1 x 10^{-4} M NaN_3 to the washed cells. As the concentration of the inhibitor decreased from 1 x 10^{-4} to 1 x 10^{-5} M NaN_3, a sharp reduction in spore germination occurred. The addition of the KCN had little or no effect upon the test bacteria. *Pseudomonas* Spp., *Bacillus* FZ and *Micrococcus* N2 were not affected by added metabolic inhibitors.

Discussion

There are 3 orders of bacteria that are prominent in the soil, namely, Pseudomonadales, Eubacteriales and Actinomycetales (1). This study reveals that soil isolates of 12 genera of these 3 orders produce a fungistatic principle. This suggests that the fungistasis phenomenon is widespread among soil borne bacteria.

In some cases, there were differences in the fungistatic activity of the different isolates of a given genus. Also, the 2 test fungi were not equally sensitive to all isolates. For example, the isolates of the genus *Achromobacter* varied in fungistatic activity and the isolate of *Rhizobium* spp. was not fungistatic to the spores of *Pestalotia macrotricha* but inhibited germination of spores of *Trichoderma viride*.

The difference in the fungistatic activity among the genera and isolates of the same genus suggests that the various bacteria either produce different fungistatic substances or the same substance in varying quantities.

Most previous work concerned with fungistasis used soil as the source of the principle. Because of the chemical and physical complexities of the soil, fungistatic assays are difficult to duplicate. Consequently, one of our objectives was to develop methods for assay of the fungistatic activity of soil isolates in a soil-free medium.

When fungistasis is studied *in vitro*, it is important that this phenomenon is not confused with the effects caused by the accumulation of metabolic end products and autolysis of the bacterial cells. By collecting the bacteria on a sterile millipore pad, washing the pad with sterile water and inverting the pad in a petri dish (Method 1) this was avoided. In this position the pad prevented intimate contact between the bacteria and spores but provided moisture for the diffusion of the fungistatic principle. In the other assay methods used, the effects of other metabolites and autolysis were minimized by repeated washing of the cell suspensions by centrifugation and resuspension before testing *in vitro*. The test period was short (24 hr.) so that there was little time for accumulation of metabolic by products which might interfere with the measurement of fungistatic activity.

The pH range of the medium on which fungistatic assays were conducted was critcal for conidia of *T. viride*. If the bacterial suspension to be used in an assay was above pH 6.9 spore germination was curtailed. For accurate measurement of the fungistatic activity, it was necessary to adjust the pH to 5.7-6.5 Treatments were discarded where there was a change in the pH during the 24 hr. incubation period for spore germination.

The number of bacteria per unit volume of medium required to produce total fungistasis of the test fungi was 10^7 to 10^9 cells/ml. The total number of bacteria per gram of soil as determined by direct microscopy provide values on the order of 10^8 to 10^9 cells/gm (1). The total population of any single species in soil is far less than the population used in the fungistatic assays because of the lack of nutrients, space, and/or due to antagonism. This suggests that the diverse population of soil bacteria produces a common substance inhibitory to spore germination. Another explanation is that there are populations of soil bacteria localized in the ecological niches where food and other factors are not limiting, thus giving sufficiently large populations to provide the concentrations necessary for spore inhibition.

Bacteria were subjected to metabolic inhibitors to determine the effect on production of the fungistatic principle. The concentrations of metabolic inhibitors used were not high enough to be fungistatic to conidia of the test fungi. It was assumed that the fungistatic principle was produced during aerobic respiration. Cyanide acts as an inhibitor when the enzyme occurs as ferricytochrome oxidase, whereas, azide inhibits enzyme action when it occurs as ferricytochrome oxidase, (11). Cytochrome oxidase of bacteria may differ from that found in other cells and may differ between species as well (4).

With *Achromobacher* F99, the highest concentration of azide suppressed the production of the fungistatic principle as evidenced by the sharp decrease in spore germination when a 10-fold dilution of the metabolic inhibitor was assayed. *Bacllius* FZ was not affected by the metabolic inhibitors at any concentrations used. These results agree with Clifton (4) in that there might be a difference in the cytochromes involved in the various bacteria. The results also suggest that the cytochrome enzymes are not involved in the aerobic respiration of the bacteria and the subsequent synthesis of the fungistatic principle. This

can be speculated from the standpoint that the cyanide failed to suppress the bacterial production of the fungistatic principle. Smith (10) pointed out that, in a number of instances, observations on the effects of inhibitors on the respiration of bacteria indicated that the cytochrome C oxidase system could not be present. Our results in this study showed that some of the most active producers of fungistatic principle, namely *Pseudomonas* spp., *Micrococcus* N2 and *Bacillus* FZ, were not affected in the presence of the metabolic inhibtors.

Summary

Isolates of 12 different genera of bacteria and actinomycetes from soil were fungistatic to the test fungi *Trichoderma viride* and *Pestalotia macrotricha*. Differences in fungistatic activity occurred among the genera and, in some cases, among isolates of the same genus. The 2 test fungi were not equally sensitive to all isolates. This suggests that either different fungistatic substances are involved or the same substance is produced in varying quantities.

In most cases, the growth medium had no effect upon production of the fungistatic principle, *in vitro*. The principle was produced by the bacteria in the logarithmic phase of growth and as resting cells. The cell population necessary to completely inhibit spore germination of the test fungi was from 10^7 to 10^9 cells/ml. Fungistatic activity was highest when the bacteria were grown at optimum temperatures.

The metabolic inhibitors sodium azide and potassium cyanide interfered with production of the fungistatic principle with certain organisms. It is suggested that either the bacteria have different cytochromes or that cytochrome oxidase is not involved in aerobic respiration and the subsequent synthesis of the fungistatic principle.

Literature Cited

1. Alexander, M. 1961. Introduction to Soil Microbiology. John Wiley and Sons. Inc., New York.
2. Brian, P. W. 1960. Antagonistic and competitive mechanisms limiting survival and activity of fungi in soil, p. 115-120. *In* The Ecology of Soil Fungi, Liverpool Univ. Press.
3. Chinn, S. H. F. and R. J. Ledinbham. 1957. Studies on the influence of various substances on the germination of **Helminthosporium sativum.** Canad. J. Bot. **35**:697-701.
4. Clifton, C. E. 1957. Introduction to Bacterial Physiology, p. 129. McGraw-Hill Book Co., Inc., New York.
5. Dobbs, C. G. and W. H. Hinson, 1953. A widespread fungistasis in soils. Nature, Lond. **172**:197-199.
6. Jackson, R. M. 1958. An investigation of fungistasis in Nigerian soils. J. Gen. Microbiol. **18**:248-258.
7. Lingappa, B. T. and J. L. Lockwood 1961. The nature of the widespread soil fungistasis. J. Gen. Microbiol. **26**:473-485.
8. Lockwood, J. L. 1959. **Streptomyces** spp. as a cause of natural fungitoxicity in soils. Phytopathology **49**:327-331.
9. Park, D. 1955. Experimental studies on the ecology of fungi in soil. Trans. Brit. Mycol. Soc. **38**:130-142.
10. Smith, L. 1954. Bacterial cytochromes. Bac. Rev. **18**:130-160.
11. Thomas, M. S., S. L. Ranson and J. A. Richardson. 1958. Plant Physiology. J. and A. Churchill Ltd. London. p. 87.
12. Warcup, J. H. 1959. Studies on the occurrence and activity of fungi in a wheatfield soil. Trans. Brit. Mycol. Soc. **40**:237-262.

Aerobic Heavy Sludge Digestion

Craig R. Hassler and Robert I. Fletcher, DePauw University

In recent years there has been an increasing amount of research on the operation of sewage and refuse disposal methods. One of the most recent fields of study has been that of heavy sewage sludge and garbage digestion by aerobic means. Heavy sludge is the non-suspended residue material which is collected from the bottom of the settling tanks of a sewage treatment plant. This sludge should not be disposed of in its raw state and further treatment is necessary before the heavy sludge can be safely disposed of or utilized.

The disposal of heavy sludge is the greatest problem in a sewage treatment works because of the difficulty of handling and the great amount of time required to stabilize the material under conditions available. At the present time many sewage digestion plants handle the heavy sludge by an anaerobic digestion method. The sludge is placed into a closed tank which is similar to a floating-top gas storage tank. Controlled temperatures are applied to the sludge and it is allowed to be digested by microorganisms under anaerobic conditions. Methane is collected as a by-product and is sometimes utilized as fuel to heat the sludge and as fuel for other purposes. However the anaerobic process of heavy sludge digestion involves expensive equipment and, on the average, requires about 30 days for stabilization.

It would be desirable to have a more efficient and less expensive system to handle the same task. A system would be desirable making use of the highly efficient principles of aerobic metabolism, such as that used in the digestion of the light suspended solids found in the liquid portion of the sewage.

Aerobic digestion has been partially investigated at Michigan State University. A digester was designed to digest garbage under aerobic conditions. The device was built on a rotating drum principle which would be costly to maintain and construct on a large scale (Figure 1).

The Fairfield Engineering Company, Marion, Ohio, has been investigating aerobic digestion of garbage on a commercial basis in an experimental plant, but digestion of the material was slow and undesirable odors developed.

In an effort to solve some of the problems encountered by the company, a small pilot plant was built in our laboratories following basically the design of the Fairfield Engineering Company. From the information available, it appeared that the limiting factor to the success of the project might lie in the method and amount of air supply to the sludge digestion system. In the small pilot plant, careful consideration was taken to incorporate a variable air supply.

The pilot model (Figure 1) was constructed from a 25 gallon steel drum, 22 inches in diameter, with a diffusion plate installed on the bottom of the tank. The purpose of the plate was to diffuse compressed air up through the heavy sludge in the tank. The diffusion plate was made of

[1]Financed in part by the Fairfield Engineering Company, Marion, Ohio.

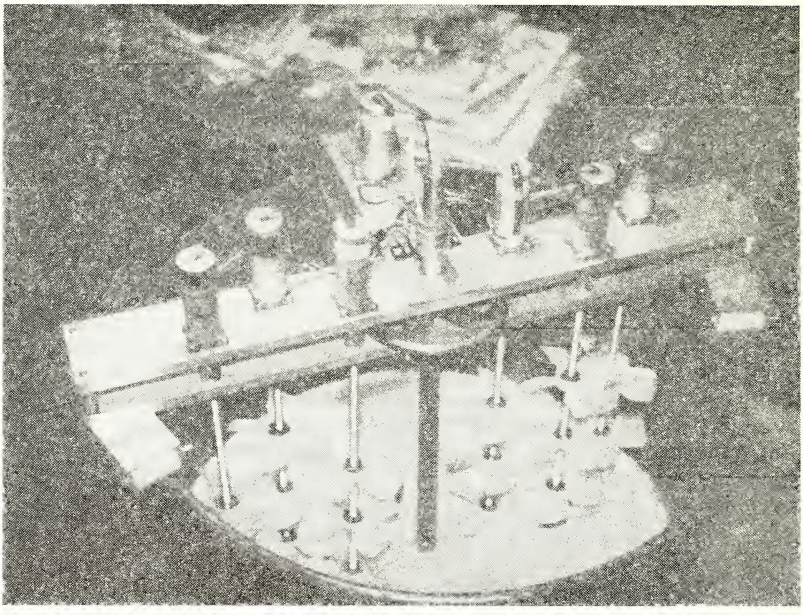


Figure 1. Pilot model of aerobic digester.

sheet metal in which many fine holes were drilled to allow the maximum amount of air contact with the sludge. A converted refrigerator compressor with appropriate control valves was used to supply air.

The most unusual part of the digester was the mixing mechanism. It is primarily a rotating bridge with independently rotating impellers. The bridge was constructed of an aluminum "C" channel and supported on nylon rollers which rested on the edge of the tank. Attached to the bridge were seven motors necessary to propel the mechanism. Each of six motors turned a shaft, each of which had four nylon impellers attached for stirring the sludge. The seventh motor rotated the entire bridge 360 degrees by means of a gear reduction mechanism. This device provided for complete mixing of the sludge. Non-corrosive parts were used wherever practicable.

The entire digester was placed inside of an isolette constructed of three mm plastic sheeting (polyethylene) 3x3x4 feet. The isolette was sealed to prevent the escape of any un-wanted odors in the event the digestion did not proceed as planned. The chamber was kept at a positive pressure and was vented through a water trap into a sewer drainage system.

Five gallons of fresh sludge was obtained from the bottom of the primary settling tanks of the Greencastle Municipal Sewage Treatment Plant. The sludge was diluted to ten gallons (12% by weight solids). Air pressure was supplied to the diffusion plate and the speed control was set to give the bridge a rotation speed of ¾ rpm. The impellers had a rotation speed of 6 rpm. The initial experiment gave a more desirable rate of digestion than had been obtained before and a stable

product resulted after six days. A slight odor was produced during the digestion which indicated the possibility of some anaerobic digestion in "dead" spots at the bottom of the digestion chamber. The air supply was redesigned to increase air input and the rotation speeds increased which resulted in more rapid digestion with very little odor.

For following runs, the sludge was not diluted, but run at 25% by weight solids, pH 5.4 and temperature of 24 degrees centigrade. It was found that these conditions held steady for the duration of each run.

These primary experiments were repeated and the variables increased to the maximum limitations of the pilot machinery. The product showed that digestion was taking place as planned, but the optimum conditions had not yet been established. It was evident that three basic improvements would have to be made, namely, improved air circulation, better agitation, and the amount of water present would have to be reduced.

The above conditions were incorporated by the Fairfield Engineering Company, e.g. reduced water content and the introduction of large volumes of air into the pulverized garbage mixture through a diffusion system. At present in the large experimental plant, stabilized material is being produced from pulverized garbage in about five days at an operating temperature of 160-170 degrees F.

Further experiments are planned with an improved model of the original unit which should allow for the optimum conditions to be found. Also work is being done to find practical uses for the final product, possibly as a soil conditioner.

The perfection of an aerobic heavy sludge and garbage digestor will allow for a great increase in the efficiency of most sewage treatment plants at a minimal cost. The present anaerobic digestion tanks of most sewage plants could be easily converted to the above aerobic system with a great reduction in time for stabilization of raw product. Such a unit could handle the sewage and garbage disposal problems of a community simultaneously.

Literature Cited

1. American Public Health Asssociation. Standard Methods for the Examination of Water and Waste Water. 1962. Eleventh Edition.
2. Folwell, A. P. 1936. Sewerage, J. Wiley and Sons.
3. Hopkins, E. S. and F. B. Elder. 1951. The Practice of Sanitation. Williams and Wilkins.
4. Schulze, K. L. 1962. Continuous Thermophillic Composting. Applied Microbiology 10: 108-122.

BOTANY

Chairman: P. A. ORPURT, Manchester College
JOHN F. SCHAFER, Purdue University, was elected chairman for 1965

ABSTRACTS

A New Fungus on the Marine Phanerogram *Thalassia testudinum.* P. A. ORPURT, Manchester College.—The herbaceous flowering plant known as turtle-grass, *Thalassia testudinum* König, distributed in extensive submarine beds throughout the Caribbean and the Gulf of Mexico, occurs along both coasts of Florida and is especially abundant in the Miami area where it forms the dominant vegetational community to depths of 10 meters.

Lindra thalassiae, a new species of scolecosporous pyrenomycete, has been isolated in considerable abundance from necrotic lesions on *Thalassia* leaves. This represents the first isolation of a fungus from this ecologically important primary producer of carbohydrate.

A Multifaceted Approach to Teaching Botany. PHILLIP SPARKS and S. N. POSTLETHWAIT, Purdue University. Many of the current problems in education can be alleviated to some degree by refocusing our attention on the learning process. Two basic ideas must be taken into consideration: (1) Learning requires involvement of the learner at a pace and a time optimal for him. (2) Opportunities should be provided for repetition, concentration, multi-sensory exposure to subject matter, use of a medium appropriate to the nature of the subject matter, an appropriate sequencing of learning events, and interaction with fellow students and instructors. It is possible and practicable to totally restructure a course in such a way as to provide an opportunity for each student to participate in these learning activities without the loss of conventional procedures which contribute to the learning process.

In a four-hour credit course in freshman botany at Purdue University, the restructuring has consisted of three study sessions: one hour of general assembly, scheduled; one hour of small assembly, scheduled; and four hours of independent study, unscheduled.

The general assembly involves all students in the course and is an occasion for all students to meet the senior instructor, to set an intellectual tone for the course, and to enable the students to accomplish many of the experiences which can best be done vicariously and in large groups.

The small assembly corresponds to a conventional recitation section; however, many kinds of activities which can best be accomplished in groups of thirty are done during this session. These may involve discussion of demonstrations by the instructor, quizzes of the conventional type, and identification with an instructor for administrative purposes.

The independent study session is conducted in a laboratory specially designed for this purpose and is kept open from 7:30 AM until 10:30 PM Monday through Friday. The student comes in at his convenience and signs in on arrival on his personal record card. The student places

this card in a numbered slot which assigns him to one of thirty booths, all of which are set up identically with the materials for the week's work. Each booth is equipped with a tape player, appropriate tapes, a microscope, live specimens, 8 mm loop film projector and other materials which are needed for the week's work. The senior instructor, via audio tape, programs the student through a series of learning events. These events may involve collecting data, doing experiments, examining specimens, reading specified material, comparing specimens with diagrams, and other activities considered useful to the learning process.

With this procedure, it has been possible to include every conventional learning experience and at the same time reduce the space required for a four-hour conventional equivalent of 500 students from two laboratories to one laboratory, improve the performance of the students at all levels, reduce the amount of staff required, enhance the personal contact of instructors and students, and to serve more students with existing staff.

A Virus Disease of Corn in Indiana. A. J. ULLSTRUP, Purdue University.—In 1963 a disease of corn was found in the Ohio River bottomlands of Dearborn, Ohio, Switzerland and Jefferson counties. Symptoms were similar to those of a disease reported in 1962 and in 1963 in the river bottomlands of Ohio and Mississippi. The disease has become more widespread and prevalent in 1964.

Early symptoms on corn are characterized by a finely stippled mosaic of light and dark green on the youngest leaves, together with a shortening of the upper internodes so as to impart a "feather-duster" appearance of the plants. With maturation the mosaic disappears and a general chlorosis with some reddish-purple coloration of leaves becomes evident. Ears on diseased plants may range from those that are normal to those that are completely barren. Tillering and excessive development of adventitious buds at the nodes are only rarely seen. Occasionally both aerial and underground roots exhibit abundant secondary branching.

The inciting agent of the mosaic symptom can be mechanically transmitted to healthy corn seedlings. Symptoms appear in corn seedlings about 72 hours after inoculation.

Under field conditions Johnsongrass, crabgrass, barnyard grass and green, yellow and giant foxtail show the mosaic symptom. The inciting agent of this symptom is mechanically transmissable from these wild grasses to corn seedlings. Johnsongrass may act as a perennial host. Marked differences are evident in resistance to the virus among genotypes of corn.

The identity of the virus is unknown. A complex may be involved which includes corn stunt and some other known or unknown virus, the latter component being mechanically transmissable. Or, a single, heretofore undescribed virus may be the inciting agent of the disease.

Zygote Germination in Astrephomene. A. E. BROOKS, Indiana University.—Recently methods have been employed to bring about mass zygote germination in the colonial green flagellate *Astrephomene gubernaculifera*. Following gametic union the zygotes are illuminated for at least 24 hours, plated on solid medium, and placed in the dark for a

minimum of six days. The dark matured zygotes are re-plated on fresh medium and placed in the light. 90-95 percent germination is evident within two hours of replating.

The first morphological manifestation of zygote germination is the appearance of a lens shaped hyaline area adjacent to the wall of the otherwise tan granular zygote. The wall in this area becomes thin and begins to bulge giving the zygote an ellipsoidal character. As the protoplast becomes separated from the wall, two flagella become evident. An irregular opening develops in the thin wall, and the protoplast is released, sometimes violently. After a swarming period the biflagellated gone settles and undergoes a series of rapid bipartitions to form a small colony. The entire process from replating to gone colony may occur in less than four hours.

Inheritance of Resistance to Loose Smut in Three Winter Barleys[1]

HENRY SHANDS, FRED L. PATTERSON and
JOHN F. SCHAFER, Purdue University

Loose smut of barley, caused by *Ustilago nuda* (Jens.) Rostr., is an important disease in humid and subhumid regions. The most practical control is by use of resistant varieties, but many commercial barley varieties do not have satisfactory resistance. Breeding for resistance is facilitated by knowledge of inheritance of available resistance and the contribution of each genetic factor concerned. Knowledge of the chromosome bearing each factor, its location on the chromosome, and linkages to easily identified marker genes is also desirable.

Studies, primarily with spring barleys, indicate that resistance generally is inherited simply. One factor pair, sometimes 2, usually dominant, controls resistance. Of 7 genes assigned symbols, only un_7 is recessive. Genetic symbols assigned and varietal sources of resistance are: Un (Trebi), Un_2 (Missouri Early Beardless), Un_3 (Jet), Un_4 (Dorsett), Un_5 (Wis. X173-10-5-6-1), Un_6 (Jet), and un_7 (Anoidium) (1, 5, 6, 7, 8, 9, 10, 15, 16, 20). Genetic studies also have been reported for other sources of resistance, but the relation of these resistances to those assigned symbols has not been established (4, 6, 10, 11, 12, 23).

Loose smut resistance, Un, is linked to stem rust reaction, Tt (1, 18). Attempts to find associations of other marker genes with resistances were unsuccessful (7, 8, 11, 16) except for a possible linkage of the 2-row character VV with Abyssinian resistance (11). The value and uses of chromosomal interchange stocks, hereafter referred to as translocation stocks, for placing unlocated genes in linkage groups have been described by Burnham (2).

Materials and Methods

Saru (CI 5185) from Korea, Milton (CI 4966) from Russia, and Missouri B696 from a cross of Missouri Early Beardless x Kentucky 2, all obtained from J. M. Poehlman, University of Missouri, were studied in crosses with Mars translocation stocks and susceptible Purdue 466A7-7-7-2-2-7. Saru, Milton, and Missouri B696 were reported free from or low in smut infection (3, 10, 13). A covered-type selection, Saru-16, was used rather than the mixed naked and covered Saru parental stock. Natural infection in Purdue 466 at Lafayette, Indiana, has ranged from 4 to 20% over the last 8 years.

Translocation stocks of Mars (CI 7015) utilized were T1-5b, T1-6a, T2-6a, T3-4a, T3-7a and T4-5a (14). Chromosomes 2 and 7 were represented once in translocations in these stocks; all others twice. An indication of linkage of a resistance factor with the breakpoints of 2 translocation stocks would establish the resistance factor on the common interchange chromosome and localize the position from recombination

[1]Journal Paper No. 2051 of the Purdue University Agricultural Experiment Station. Contribution from the Departments of Agronomy, and Botany and Plant Pathology. Part of a thesis submitted by the senior author in partial fulfillment of the requirement for the Ph.D. degree while a National Science Fellow.

values. Plants heterozygous for translocations were identified by semi-sterility of the spike.

Other marker genes were utilized where available. Distinguishing characteristics of the varieties are presented in Table 1. All are 6-

TABLE 1.
Distinguishing characteristics of five parental varieties.

Variety or selection	C.I. number	Awns[1]	Rachilla hairs	Stem rust resistance	Spring (S) or winter (W) habit
Milton	4966	r	S	t	W
Missouri B696		R	s	t	W
Saru-16	5185-16	R	s	t	W
Purdue 466A7-7-7-2-2-7	10666-7	R	S	t	W
Mars (translocations)	7015	r	S	T	S

[1]Genetic symbols: Rough vs. smooth awns (R,r); Long vs. short rachilla hairs (S,s); Stem rust resistance vs. susceptibility (T,t).

rowed barleys with white kernels and adherent lemma and palea. The selections of Milton and Saru differ from descriptions of the original introductions but are similar to selections made by other workers.

Race 1 of *U. nuda* (21) present in the Lafayette, Indiana, area was used. Initial inoculum was low in viability, and the first inoculated population showed low infection. For this reason, populations grown in the field and greenhouse in 1960 were considered together. Subsequent inoculum obtained fresh from susceptible Purdue 466 was highly viable, and other populations grown are considered in a second group (Table 2). Inoculation was with dry teliospores using a 20-gauge shortened hypodermic needle and medicine dropper bulb as described by Shands and Schaller (17). Hybrids were inoculated approximately 24 hours after pollination.

Part of the hybrid seed was smut-inoculated to obtain an F_1 infection level. Inoculation of approximately ½ of the heads on an F_1 plant provided an F_2 smut-infection test, and the noninoculated heads provided a sister F_2 population which could be inoculated, classified at harvest for the genetic markers, and carried to an F_3 smut-infection test.

Crosses of the smut-resistant winter barleys with each other and with susceptible Purdue 466 were grown in the greenhouse or field as follows. Parents, F_1, F_2, and backcross progenies for a greenhouse smut-infection reading were vernalized in flats in a 36° F cold room for 60 days and transplanted to 4-inch pots or left thinly planted in flats. Parental, F_1, and F_2 populations were spaced in the field at 3 inches in rows 1 foot apart in the fall of 1960 and 1961. Limited winter damage occurred in 1960, and severe winter damage eliminated most F_1 plants as well as an F_2 planting in 1961.

F_2 populations of crosses of the 3 smut-resistant winter lines to the 6 spring translocation stocks were spring-sown in 1960, 1961 and 1962. Each plant of the noninoculated F_2 populations was classified for fertility versus partial sterility and for marker genes segregating in the specific cross. In the subsequent spring the smut-inoculated seed

TABLE 2.
Reactions of parental and F_1 and F_2 hybrid plants to artificial inoculations with *Ustilago nuda*, averaged into 2 groups on the source of inoculum.

Parent or cross	Generation	Group I* plants tot†	Group I* plants inf‡	Group II plants tot†	Group II plants inf‡
		No.	%	No.	%
Purdue 466	parent	87	35	254	51
Mars (translocation stocks)	parent	63	13	896	28
Milton (C.I. 4966)	parent	70	0	406	0
Purdue 466 x Milton	F_1	—	—	39	0
Purdue 466 x Milton	F_2	124	3	153	12
Purdue 466 x F_1 (Pur. 466 x Milton)	F_1	—	—	19	63
Mars (trans.) x Milton	F_1	48	0	—	—
Mars (trans.) x Milton	F_2	199	3	1093	17
Mo. B696	parent	71	3	300	7
Purdue 466 x Mo. B696	F_1	—	—	6	67
Purdue 466 x Mo. B696	F_2	117	12	124	44
Purdue 466 x F_1 (Pur. 466 x Mo. B696)	F_1	—	—	8	63
Mars (trans.) x Mo. B696	F_1	45	31	—	—
Mars (trans.) x Mo. B696	F_2	331	8	1541	36
Saru-16 (C.I. 5185-16)	parent	37	0	308	5
Purdue 466 x Saru-16	F_1	—	—	33	42
Purdue 466 x Saru-16	F_2	107	16	—	—
Purdue 466 x F_1 (Pur. 466 x Saru-16)	F_1	—	—	34	85
Mars (trans.) x Saru-16	F_1	52	39	—	—
Mars (trans.) x Saru-16	F_2	345	12	1942	40
Saru-16 x Mo. B696	F_1	16	6	38	5
Saru-16 x Mo. B696	F_2	—	—	176	19
Saru-16 x Milton	F_1	17	0	1	0
Saru-16 x Milton	F_2	—	—	250	13
Mo. B696 x Milton	F_1	17	0	9	0
Mo. B696 x Milton	F_2	—	—	237	13

* Group I = low viability inoculum. Group II = high viability inoculum.
† tot. no. = total number of plants examined at flowering time.
‡ inf % = % of total number of plants infected.

from each F_2 plant of the 1960 and 1961 series was planted in an F_3 progeny row. Smut percentages were calculated for rows containing 10 or more plants. Where insufficient plant numbers occurred in 1961, the row was repeated in 1962 if reserve seed was available, and the data were combined. A cool, wet spring in 1961 vernalized nearly all the winter habit plants of these segregating populations. In both 1961 and 1962, the young heads of the winter-type plants were examined for smut infection with the aid of a dissecting needle.

Races 15B and 56 of *Puccinia graminis* Pers. f. sp. *tritici* were inoculated into spreader rows of Manchuria (CI 2947) to test for stem

rust resistance conditioned by the T gene, with good tests obtained in 1961 and 1962.

Genetic symbols, used for convenience in the analysis, are not intended for permanent assignment.

Results and Discussion

INHERITANCE OF RESISTANCE—Infection percentage data are presented in Tables 2 and 3. Data in Table 2 are not comparable

TABLE 3.

Frequency distribution of smut infection percentages in progenies of F_2 plants from crosses of resistant varieties with Mars translocation stocks, artificially inoculated with *U. nuda*.

	F^3 smut infection percentages classes					
Cross	0	1-10	11-20	21-30	31-40	41-50
Mars (trans.) x Milton	133	85	64	36	28	21
Mars (trans.) x Mo. B696	56	112	127	116	105	58
Mars (trans.) x Saru-16	39	97	110	111	77	73

	F^3 smut infection percentages classes					
Cross	51-60	61-70	71-80	8190	91-100	Total plants
Mars (trans.) x Milton	15	9	3	0	1	395
Mars (trans.) x Mo. B696	47	34	26	18	11	710
Mars (trans.) x Saru-16	36	23	19	4	0	589

between groups I and II; group I involved low viability smut inoculum, and group II high viability inoculum. The frequency distribution data in Table 3 were obtained from detailed data by summing the number of F_2 plants having progenies in each smut infection class for the crosses of each resistant variety with the 6 Mars translocation stocks. The division of frequency distributions into genetic classes is arbitrary although the choices appear valid in consideration of parental data. The simplest hypothesis in keeping with the data was selected, and the fit of the data to that hypothesis is shown in Table 4.

Purdue 466, the susceptible parent, had 35 and 51% infection in groups I and II, respectively, and was sufficiently susceptible in all tests for the level of infection to be distinguished from infection levels of the 3 resistant parents (Table 2). Levels for the resistant parents were, for groups I and II: Milton, 0 and 0%; Missouri B696, 3 and 7%; and Saru-16, 0 and 5%. Mars translocation stocks had 13 and 28% infection in groups I and II. Although the translocation stocks served in the role of a susceptible parent, the difference obtained in infection level between Mars and each resistant parent was not great.

Neither the translocation stocks nor Mars itself were crossed with Purdue 466, but the differences of infection indicated a physiological difference in susceptibility between the 2 varieties, possibly attributable to a factor or factors conditioning moderate resistance in Mars. Such weak factors, Un_2 and Un_5, have been proposed by Livingston (7) and Schaller (16) to explain similar levels of resistance. The data from crosses with Mars translocation stocks are analyzed 2 ways, either con-

TABLE 4

Assigned resistance factors and proposed class divisions for progenies of F_2 plants from crosses of resistant varieties with Mars translocation stocks, artificially inoculated with *U nuda*.

	Milton	Missouri B696	Saru-16
	Analysis of resistant parents based on Mars having no resistance factor		
% infection of resistant parents	0	7	5
Total progenies of F_2 plants	395	710	589
Proposed class division	0-20:21-100	0-10:11-100	0-10:11-100
Observed ratio	282:113	168:542	136:453
Expected ratio	3:1	1:3	1:3
P value	.05-.10	.4-.5	.2-.3
Class genotypes	AA-:aa	cc:C-	dd:D-
Assigned parental genotypes	AA x aa	cc x CC	dd x DD
Resistance factor	A	c	d
	Analysis of resistant parents based on Mars having a weak resistance factor		
% infection of resistant parents	0, 28*	7, 28	5, 28
Total progenies of F_2 plants	395	710	589
Proposed class division	0-20:21-50:51-100	0-10:11-50:51-100	0-10:11-45:46-100
Observed ratio	282:85:28	168:406:136	136:334:119
Expected ratio	12:3:1	4:9:3	4:9:3
P value	.2-.3	.6-.7	.4-.5
Class genotypes	A—:aaB-:aabb	cc—:C-B-:C-bb	dd—:D-B-:D-bb
Assigned parental genotypes	AAbb × aaBB	ccbb × CCBB	ddbb x DDBB
Resistance factor	A, B*	c, B	d, B

*First entry represents parent; second entry represents Mars parent.

sidering the Mars infection as the level of susceptibility or considering Mars to have a weak factor for resistance. The P value for the suggested ratio along with class divisions and possible class genotypes of the F_2 frequency distribution are presented in Table 4 for each hypothesis. Because of the somewhat arbitrary class divisions, frequency distributions have not been divided into more than 3 classes for any hypothesis. Using the hypotheses proposed for the F_2 data from Mars crosses, F_2 infection percentages for both Mars and Purdue 466 crosses are predicted from parental values and are shown in Table 5 along with the observed infection percentages for the given cross.

Milton—The value of Milton resistance is suggested by the immune reaction of the parent and F_1 poulations from crosses of Milton with susceptible Purdue 466 and the other resistant parents. The im-

mune reaction of the parent and F_1 populations from crosses of Milton parents indicates complete dominance.

TABLE 5

Observed reaction of F^2 plant population artificially inoculated with *U. nuda* and predicted reaction from parental data for proposed mode of inheritance of resistance.

Cross	Expected F_2 ratio	Group I* Infection		Group II Infection	
		Observed	Predicted	Observed	Predicted
		%		%	%
Purdue 466 x Milton	3:1	3	9	12	13
Mars (trans.) x Milton	3:1	3	3	17	7
Purdue 466 x Mo. B696	1:3	12	28	44	41
Mars (trans.) x Mo. B696	1:3	8	10	36	23
Purdue 466 x Saru-16	1:3	16	27	–	–
Mars (trans.) x Saru-16	1:3	12	9	40	22

*Group I = low viability inoculum: Group II = high viability inoculum.

The hypothesis that the resistance in Milton is controlled by a single, completely dominant factor is suggested by the F_3 data of the Mars translocation crosses. With Mars at 28% infection representing the homozygous recessive condition for the Milton factor, F_3 lines having more than 20% infection might reasonably be considered susceptible and those with 20% or less, resistant (Table 3). The ratio, 282 resistant: 113 susceptible, fits a 3:1 Chi-square test with a P value of .05-.10 (Table 4).

Considering Milton to have a single dominant factor, A, and Mars a weak but dominant factor different from that in Milton, B, the F_3 distribution might be divided as follows. The 0-20% infection classes would represent A- individuals, the 21-50% classes the Mars types aaB-, and the 51-100% classes, aabb. The expected 12:3:1 ratio is fit by these data with a P value of .3-.4 for the Chi-square goodness of fit test.

The low infection percentages in all F_2 populations from crosses with Milton may indicate the presence of more than one dominant factor, or resistance of the maternal tissue of the F_1 plants. On the contrary, 63% infection in the backcross Purdue 466 x F_1 (Purdue 466 x Milton) is equal to that of the susceptible parent for the same test and is greater than would be expected with a single, dominant factor.

Metcalfe and Johnson (10) found a single dominant gene governing resistance to races 1, 2, and 3 in a spring-type derivative from the Milton variety in publication since completion of this research. They showed that the gene was independent of the resistances of Jet (Un_3 and Un_6) and of Valkie.

The evidence from these 2 studies in general supports the hypothesis of a single, completely dominant resistance gene in Milton.

Missouri B696—The infection levels of Misssouri B696 were 3 and 7% in groups I and II (Table 2). The 6 F_1 plants from the cross with Purdue 466 gave 67% infection, comparing closely to a 63% infection

in Purdue 466 in the same test. The backcross Purdue 466 x F_1 (Purdue 466 x Missouri B696) had 63% infection. These data indicate that Missouri B696 may contain a recessive factor. The combined group II F_2 infection level of 44% approximates the predicted 41% (Table 5). The expected F_2 value for group I of 28% is not closely approximated by the 12% observed but this could be explained by the low viability inoculum.

In the F_3 distribution of the cross with Mars (Table 3), the 1-10% infection class is similar in reaction to Missouri B696. Considering the 0-10% classes to be resistant, the observed ratio of 168 resistant: 542 susceptible fits the expected 1:3 ratio with a P value of .4-.5 for the Chi square test (Table 4).

Again considering Mars to possess a dominant, weak factor for resistance, B, and denoting resistance from Missouri B696 as c, the 0-10% classes might represent homozygous resistant genotypes cc—. The 11-50% classes contain C-B- genotypes having their distribution around the Mars infection level. The 51-100% classes characterize susceptible genotypes, C-bb. The data fit the 4:9:3 expected ratio with a P value of .6-.7 and again support the hypothesis of a single recessive factor in Missouri B696.

Saru-16—This variety reacted similarly to Missouri B696. Saru-16 had 0 and 5% infection in groups I and II. The F_1 of the cross with Purdue 466 showed 42% infection while the backcross Purdue 466 x F_1 (Purdue 466 x Saru-16) had 85% infection in group II (Table 2). These values suggest the presence of a recessive factor.

The F_2 infection level in group I was 16%. Although no group II data were available, it might be estimated from the increased F_2 infection in group II of the cross of Mars and the similarly reacting Missouri B696 that the infection level would be in the range of the predicted 41% (Table 5). The group I value of 16% is below that predicted from the parental reactions, as it was for Missouri B696, and may be due to the low viability inoculum.

The F_3 distribution from crosses with the Mars translocations also appears similar to that of Missouri B696 (Table 3). The Saru-16 infection falls into the 1-10% level, and the 0-10% classes might be considered resistant. The observed ratio, 136 resistant: 453 susceptible, fits the expected 1:3 ratio with a P value for the Chi-square test of .2-.3 (Table 4).

Denoting the Saru-16 resistance as d, and retaining B for the Mars factor, the distribution may again be divided with the 0-10% classes representing Saru-16 resistance, dd—. Using a 5% interval, the 11-45% classes would comprise D-B-. The susceptible classes, 46-100%, contain D-bb. The 4:9:3 expected ratio is fit with a P value of .4-.5 for the Chi-square test.

IDENTITY OF RESISTANCES—The similar mode of inheritance of resistance in Missouri B696 and Saru-16 suggested that the same factor might be controlling resistance in each. F_1 progeny from the cross of Saru-16 and Missouri B696 showed infection similar to that of the 2 parents (Table 2). The 19% infection obtained in the F_2 of Saru-16 x Missouri B696 was considerably higher than that of either parent or

the F_1. It is suggested that the factors in Saru-16 and Missouri B696 are different.

The immune reaction of F_1 plants of crosses of Missouri B696 and Saru-16 with Milton was expected from the proposed completely dominant Milton factor. Both F_2 populations had 13% infected plants, indicating the factors of Missouri B696 and Saru-16 are distinct from that of Milton.

The conclusion that these factors are different is reasonable from consideration of the geographical source areas. Saru, introduced from Korea in 1930, would be unlikely to have the same resistance as Missouri Early Beardless from which Missouri B696 was derived. Missouri Early Beardless originated from a mass selection made in 1932 from a hooded winter barley whose origin was unknown but believed to be from one of the southern states (22). Milton, introduced from Russia in 1927, would in turn have an independent source.

LOCATION OF RESISTANCE FACTORS—Infection data from crosses of Milton, Missouri B696, and Saru-16 with the Mars translocation stocks are presented in Table 3. The number of F_2 plant progenies falling into 11 F_3 smut-infection classes was tabulated by F_2 phenotype for each marker character studied. Awn barbing and rachilla hair length (chromosome 7) and stem rust reaction (chromosome 1) were classified in the Missouri B696 and Saru-16 crosses. Only stem rust reaction was classified in the Milton crosses. The fertility versus partial sterility resulting from crossing to the translocation stocks was classified for all crosses. These data were tested with a Chi-square test for goodness of fit. Although a few ratios did not fit the expected, they appear the result of small populations or failure of semisterile plants to produce sufficient progeny for loose smut infection analysis.

To visually demonstrate possible associations, frequency distributions for each character for each cross were plotted with the number of F_2 plants possessing a given character as the ordinate and the F_3 smut infection classes (0, 1-10, 11-20,....., 91-100) as the abscissa. The frequency distributions by infection classes for the 2 F_2 phenotypes of a character were plotted on the same graph. A close resemblance between the 2 distributions for each character indicated homogeneity of the entire population and consequently implied no linkage of loose smut reaction to the genetic character against which it was plotted. To confirm the visual conclusion as to the homogeneity of these populations, the Mann-Whitney U Test as described by Siegel (19) was chosen. One of the most powerful nonparametric statistical tests, it is used to test whether 2 independent groups have been drawn from the same population.

The frequency distribution graphs and statistical tests showed no associations with translocation breakpoints or marker genes. Failure to detect such linkage, if present, might also result from the fact that Mars and its translocation derivatives could be classed as only moderately susceptible to loose smut (Table 2), resulting in a lack of separation of the resistant and susceptible distribution peaks on the graph, or that there were small populations in some crosses of Milton with the translocation stocks. With the exception of the Trebi factor (1, 18) and

possibly a factor in Abyssinian (11), smut resistance genes have eluded placement by linkage analysis in previous studies also (7, 8, 11, 16).

Summary

Milton, Missouri B696, and Saru-16 each possessed a high level of resistance to a collection of race 1 of *U. nuda*. Parental, F_1, backcross, and F_2 data from hybrids of these resistant varieties x susceptible Purdue 466A7-7-7-2-2-7 and F_3 data from hybrids of the resistant varieties x Mars translocation stocks, suggested resistance to be conferred by a dominant factor pair in Milton and a recessive factor pair each in Missouri B696 and Saru-16. Resistant x resistant hybrids indicated the resistances to be distinct from each other. Crosses of the 3 resistant varieties with Mars translocation stocks T1-5b, T1-6a, T2-6a, T3-4a, T3-7a, and T4-5a showed independent inheritance of the resistance factors from the translocation interchange points and marker genes controlling stem rust reaction, rachilla hair length, and awn barbing.

Literature Cited

1. Andrews, J. E. 1956. Inheritance of reaction to loose smut, **Ustilago nuda**, and to stem rust, **Puccinia graminis tritici**, in barley. Can. J. Agr. Sci. **36**:350-370.
2. Burnham, C. R. 1956. Chromosomal interchanges in plants. Bot. Rev. **22**:419-552.
3. Cloninger, C. K., and J. M. Poehlman. 1954. Resistance of winter barley to **Ustilago nuda** (Jens.) Rostr. Univ. of Missouri Res. Bul. 560.
4. Konzak, C. F. 1953. Inheritance of resistance in barley to physiologic races of **Ustilago nuda**. Phytopathology **43**:369-375.
5. Larter, E. N. 1962. The inheritance of loose smut resistance. II. The inheritance of resistance in three barley varieties immune to race 2. Can. J. Plant Sci., **42**:707-710.
6. Larter, E. N., and H. Enns. 1962. The inheritance of loose smut resistance. I. The inheritance of resistance in four barley varieties immune to race 2 of loose smut. Can. J. Plant Sci. **42**:69-77.
7. Livingston, J. E. 1942. The inheritance of resistance to **Ustilago nuda**. Phytopathology **32**:451-466.
8. Metcalfe, D. R. 1962. Inheritance of resistance to loose smut, covered smut and false loose smut in the barley variety Jet. Can. J. Plant Sci. **42**:176-189.
9. Metcalfe, D. R., and S. B. Helgason. 1962. Inheritance of loose smut resistance. I Inheritance of resistance to a Trebi-attacking culture of **Ustilago nuda** (Jens.) Rostr. in five barley varieties of Abyssinian origin. Can. J. Plant Sci. **42**:472-480.
10. Metcalfe, D. R., and W. H. Johnston. 1963. Inheritance of loose smut resistance. II. Inheritance of resistance in three barley varieties to races 1, 2 and 3 of **Ustilago nuda** (Jens.) Rostr. Can. J. Plant Sci. **43**:390-396.
11. Mohajir, A. R., D. C. Arny, and H.. L Shands. 1952. Studies on the inheritance of loose smut resistance in spring barleys. Phytopathology **42**:367-373.
12. Nahnmacher, J. 1932. Beitrag zur Immunitatszuchtung der Gerste gegen **Ustilago nuda** forma spec. **hordei**. Phytopath. Z. **4**:597-630.
13. Poehlman, J. M. 1949. Sources of resistance to loose smut, **Ustilago nuda**, in winter barleys of foreign origin. Agron. J. **41**:191-194.
14. Ramage, R. T., C. R. Burnham, and A. Hagberg. 1961. A summary of translocation studies in barley. Crop Sci. **1**:277-279.
15. Robertson, D. W., G. A. Wiebe, and R. G. Shands. 1947. A summary of linkage studies in barley: Supplement I, 1940-1946. J. Am. Soc. Agron. **39**:464-473.
16. Schaller, C. W. 1949. Inheritance of resistance to loose smut, **Ustilago nuda**, in barley. Phytopathology **39**:959-979.

17 Shands, H. L., and C. W. Schaller. 1946. Response of spring barley varieties to floral loose smut inoculation. Phytopathology **36**:534-548.

18. Shands, R. G. 1946. An apparent linkage of resistance to loose smut and stem rust in barley. J. Am. Soc. Agron. **38**:690-692.

19. Siegel, S. 1956. Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill Book Company, Inc. New York.

20. Skoropad, W. P., and L. P. V. Johnson. 1952. Inheritance of resistance to **Ustilago nuda** in barley. Can. J. Bot. **30**:525-536.

21. Tapke, V. F. 1955. Physiologic race in **Ustilago nuda** and techniques for their study. Phytopathology **45**:73-78.

22. Wiebe, G. A., and D. A. Reid. 1961. Classification of barley varieties grown in the United States and Canada in 1958. U. S. Department of Agriculture Tech. Bul. 1224.

23. Zeiner, W. 1932. Das Verhalten verschiedener Sommergerstenkreuzungen hinsichtlich der Anfalligkeit fur **Ustilago nuda**. Z. Zucht. A. Pflanzenzucht. **17**:229-264.

Preliminary Results in the Laboratory Culture of Planktonic Blue-green Algae

WILLIAM R. EBERLY, Manchester College

During the school year 1963-64 the writer was granted a sabbatical leave to pursue a research project at the Institute of Limnology, University of Uppsala, Sweden, entitled "Environmental requirements of planktonic blue-green algae." The project was supported largely by the National Science Foundation through grant GB-900 in conjunction with partial salary allowed by Manchester College under a sabbatical contract. The facilities of the Institute of Limnology were made available through the great kindness of the director, Dr. Wilhelm Rodhe. Appreciation is expressed at this time to all who helped make this project possible.

A large number of temperate lakes have phytoplankton communities dominated by one or more members of the Cyanophyta, the "blue-green" algae. Though many sessile or benthic species of blue-green algae have been cultivated and a great deal learned of their ecology and physiology, planktonic forms are extremely difficult to grow in laboratory conditions. Consequently, little is known through controlled experimental work of the physiology of these forms. Within the last decade or so, some progress has been made in cultivating planktonic species, chiefly by workers at the University of Wisconsin and the National Research Council at Ottawa.

Until about 1950 no truly planktonic (euplanktic) species of blue-green algae had been successfully cultivated under laboratory conditions in purely inorganic media (1,9). Gerloff *et. at.* (3) reported 22 species in culture, of which at least 5 are bonafide euplankters: *Lyngbya Birgei, Aphanizomenon flos-aquae, Diplocystis aeruginosa (Microcystis aeruginosa), Anabaena circinalis,* and *Gloeotrichia echinulata.* Most of the other species are to be considered as tychoplanktic or facultative plankters. Gorham (4) reported 11 species under culture in the laboratories at Ottawa, of which 9 are unquestionably euplanktic: *Anabaena flos-aquae, Anabaena limnetica, Anabaena spiroides, Anabaena schermetievi, Anacystis cyanea f. minor, Aphanizomenon flos-aquae, Coelosphaerium kuetzingianum, Gloeotrichia echinulata,* and *Microcystis aeruginosa.* Considerable advances have been made in understanding the physiology and ecology of *Microcystis aeruginosa* (6, 7, 12), *Aphanizomenon flos-aquae, Gloeotrichia echinulata* (11), and *Anabaena flos-aquae* (5).

In addition to the above, Staub (10) has published an extensive account of the physiology and ecology of *Oscillatoria rubescens,* the first truly planktonic species of the genus to be cultured in the laboratory, and Drews and his co-workers (2) have described a new species of planktonic blue-green alga, *Synechococcus plancticus,* which they have produced in mass culture in their laboratory. To the writer's knowledge, this represents all the euplanktic Cyanophytes in laboratory culture until just recently.

The first stated objective of the work was to obtain cultures of some of the common planktonic blue-greens. This involved among other things

the successful isolation of available forms, development of suitable media, and determining satisfactory growing conditions. Stable unialgal cultures of 5 forms never before cultured were established, of which 2 are being described as new taxa. These include: *Oscillatoria agardhii* var. *isothrix*, *Oscillatoria baltica* nov. spec., *Oscillatoria limnetica*, *Anabaena delicatula* var. *robusta* nov. var., and *Synechocystis parvula*. The cultures are being maintained at the Institute of Limnology at Uppsala and will also be available in the laboratory of the writer. A number of other forms than those listed were isolated, but were not saved, since major interest was in previously uncultured forms and especially in deep water filamentous forms, such as the *Oscillatorias*.

Colonial forms such as *Microcystis* and *Aphanizomenon* were easily isolated by means of micro pipettes. It proved to be extremely difficult to isolate single trichomes of forms like the *Oscillatorias*, partly because the filaments were so small (generally under 5 micra in diameter). Single trichomes placed in test tubes rarely survived. Perhaps the filaments, because of their low density, tended to float to the surface where they became lodged in the concave meniscus and were consequently dried out with minute amounts of evaporation of the medium. Dense samples dominated by a single species of blue-green were purified with the addition of 50ppm of Actidione, an anti-biotic with selective anti-algal properties (13). All forms except blue-greens are inhibited and eventually killed by Actidione. Such cultures were termed "working cultures" and were shown by visual examination to be unialgal, though one cannot be positive that contaminants were wholly absent.

Motile forms such as the *Oscillatorias* were isolated by plating the culture on medium solidified by the addition of 1.5 percent agar. After several weeks, in petri dishes with one half covered with opaque paper, the trichomes crawled away from any contaminating algae into the lighted half and could easily be lifted out and transferred to a culture vessel. The extremely small *Synechocystis* species (0.7-0.9 μ) was purified by filtering a culture through a membrane filter type RA (pore size 1.2 μ) which removed all known extraneous forms.

A number of culture media were tried but most formulae which have been used successfully with other types of algae seemed too concentrated for the species with which this study was concerned. The ASM medium of Gorham and his associates (6) proved quite good for nearly every form studied. Some tentative conclusions seem warranted on the basis of limited nutrient studies. Blue-greens, at least the planktonic forms, do not need a full trace element supplement. The ASM formula provides only Fe, B, Mn, Zn, Co, and Cu. It also seems likely that the iron requirements are not as rigid as in various other algae that have been studied (9). Filamentous forms, such as *Oscillatoria* and *Anabaena*, seem to require more calcium than coccoid forms. It seemed that at least 10mg/1 Ca is needed for best growth. The Ca/Mg ratio by weight also seems to be critical, with best growth being obtained where this ratio did not deviate significantly from unity. Further studies seem to clarify the nutritional requirements are needed.

For the most part, material was grown at room temperatures, i.e., 20-25° C. Very rapid growth was observed under these conditions, which does not explain the occurrence of population maxima in nature at

depths where the temperature is below this level. Illumination was provided by both ordinary fluorescent lamps and by a combination of warm tubes (heavy in the reds) and cold tubes (heavy in the blues). This combination provided a much broader, flatter spectrum of wide range than the ordinary daylight bulb with a single pronounced peak near the center of the spectrum. The effect of various spectral combinations was not determined and awaits further study. Too high a level of intensity is harmful to planktonic Cyanophytes. Good average growth occurred at about 500 lux (50 ft. candles) at the level of the culture vessels.

The most critical factor observed by the writer concerns the mode of culture. Stationary vessels, regardless of size, shape, etc., proved unsuitable for these planktonic forms. The most successful culture methods required a shaking table. Rate of shaking can be balanced with the size, shape and capacity of culture vessel to give the desired amount of agitation (generally the minimum amount of agitation required to maintain full dispersion of the algae is best). A "fermentation tower" patterned after those used by Gorham (12) was constructed, in which a flow of air through the bottom of the tube produced turbulence throughout the length of the column. This was successful with several fialmentous and unicellular forms, but growth of colonial forms under these conditions was not so good (see also 11). I found that a much lower rate of flow of air than that reported by these workers (12) was adequate. Where they used 1000 cc/min, in our work 300 cc/min (which was the lowest rate that could be measured) was sufficient.

A few very preliminary experiments were carried out with 5 species to determine the photosynthetic response (a measure of growth rates) under different combinations of light intensity and temperature. Identical aliquotes were innoculated with C-14 (as bicarbonate) and exposed to 4 different levels of light intensity at 2 ranges of temperature (12° and 20°). The major difficulty encountered was the precise measurement of light intensity. In spite of this, photosynthetic response curves at the two temperature levels (using relative light values) indicate significant species differences. The results clearly indicate that this can be a fruitful field of inquiry as soon as suitable apparatus can be devised and constructed.

Literature Cited

1. Allen, M. B. 1952. The cultivation of Myxophyceae. Archiv f. Mikrobiol. **17**:34-53.
2. Drews, G. H. Prauser, and D. Uhlmann. 1961. Massenvorkommen von Synechococcus planticus nov. spec. einer solitaren, planktischen Cyanophycee, in einem Abwasserteich. Archiv f. Mikrobiol. **39**:101-115.
3. Gerloff, G. C., G. P. Fitzgerald, and F. Skoog. 1950. The isolation, purification, and nutrient solution requirements of blue-green algae. In: The Culturing of Algae, ed. by Brunel, Prescott and Tiffany, published by the Charles F Kettering Foundation, pp. 27-44.
4. Gorham, P. R. 1962. Laboratory studies on the toxins produced by waterblooms of blue-green algae. Am. J. Pub. Health **52**:2100-2105.
5. Gorham P. R., J. McLachlan, U. T. Hammer, and W. K. Kim. 1964. Isolation and culture of toxic strains of Anabaena flos-aquae (Lynb.) de Breb. Verh. Internat. Verein. Limnol. **15**:796-804.
6. McLachlan, J., and P. R. Gorham. 1961. Growth of Microcystis aeruginosa Kutz. in a precipitate-free medium buffered with tris. Can. J. Microbiol. **7**:869-882.

7. McLachlan, J., and P. R. Gorham. 1962. Effects of pH and nitrogen sources on growth of Microcystis aeruginosa Kutz. Can. J. Microbiol. **8**:1-11.

8. McLachlan, J., U. T. Hammer, and P. R. Gorham. 1963. Observations on the growth and colony habits of ten strains of Aphanizomenon flos-aquae. Phycologia **2**:157-168.

9. Rodhe, W. 1948. Environmental requirements of fresh-water plankton algae. Symbolae Bot. Upsalienses **10**:1-149.

10. Staub, R. 1961. Erhahrungsphysiologisch-autokologische Untersuchungen an der planktischen Blaualge Oscillatoria rubescens DC. Schweiz. Zeit. f. Hydrologie **23**:82-198.

11. Zehnder, A. 1963. Kulturversuche mit Gloeotrichia echinulata (J. E. Smith) P. Richter. Schweiz. Zeit. f. Hydrologie **25**:65-83.

12. Zehnder, A., and P. R. Gorham. 1960. Factors influencing the growth of Microcystis aeruginosa Kutz. emend. Elenkin. Can. J. Microbiol. **6**:645-660.

13. Zehnder, A., and E. O. Hughes 1958 The antialgal activity of Acti-dione. Can. J. Microbiol. **4**:399-408.

Comparison of Donaldson's Woods in 1964 with its 1954 Forest Map of 20 Acres

ALTON A. LINDSEY and DAMIAN V. SCHMELZ[1]
Department of Biological Sciences, Purdue University

Donaldson's Woods is an 80-acre stand of original mixed-mesophytic forest in Spring Mill State Park, Lawrence County, Indiana. Because of many very large white oaks and tulip trees, this is the most impressive forest in the state. Following the growing season in 1954, field data were collected for construction of a two-dimensional model of 20 acres at a scale of 1:36, showing the position and basal area of each tree 4 in. d.b.h. or over. An evaluation of 9 methods of forest sampling (1) was based on this large scale map.

Ten growing seasons after the original mapping, the present writers (2), in late July, 1964, made a tree-for-tree comparison of the 20 acres as of the beginning and end of this interval. Ozalid copies of the tracing linen map sections were used in the woods, and each tree was located and measured with a diameter tape. Individuals that had grown past the 4-in. diameter threshold were added to the map; trees that had died or come down were so recorded. The map sections, assembled later in the laboratory into a flat model 37 x 18 ft., provided data for a study of population dynamics in the mature tree stratum during a decade of forest history during which almost no human disturbance affected the stand.

Trees[2] New to the Record

Since individuals smaller than 4 inches d.b.h. were disregarded both at the beginning and end of the decade, trees growing across the 4-inch d.b.h. lower limit of recorded trees were newly recorded in 1964 in the sizes from 4 to 8 inches. Table 1 gives their numbers and basal area sums for 2-inch size classes having midpoints at 5 and 7 inches, under the heading "new".

Many sugar maples and a moderate number of beech, American ash, and flowering dogwood grew across the 4-inch threshold. But only 4 small white oaks did so. The basal area sum of the new sugar maples was greater than that of the other 24 species combined.

Six individuals (Table 1) that were too small to count in 1954 had entered the 7-inch midpoint size class by 1964. Four of these were sugar maple.

The gross or absolute gain of new trees was 179 in all, or 9.1 individuals per acre, representing a gross increase in basal area of only 1.06 sq. ft. per acre from trees that were less than 4-inch d.b.h. in 1954.

---

[1]The second-named author is a teaching priest at St. Meinrad College, St. Meinrad, Indiana.

[2]Qa is **Quercus alba**, Fg **Fagus grandifolia**, As **Acer saccharum**, Co **Carya ovata**, Qr **Quercus rubra**, Ns **Nyssa sylvatica**, Ar **Acer rubrum**, Cg **Carya glabra**, Fa **Fraxinus americana**, Qv **Quercus velutina**, Lt **Liriodendron tulipifera**, Cl **Carya laciniosa**, Ov **Ostrya virginiana**, Cc **Carya cordiformis**, Cf **Cornus florida**, and others (less than 1 per cent density in tables) are **Fraxinus pennsylvanica**, **Juglans nigra**, **Sassafras albidum**, **Ulmus rubra**, **U. americana** **Carpinus caroliniana**, **Tilia americana**, **Celtis occidentalis**, **Ulmus thomasi** and **Morus rubra**.

TABLE 1

Accessions and deaths of trees in 19.57 acres in the two smallest two-inch size-classes, between the 1954 and 1964 studies. Figures for each species show numbers of individuals (No.) and sum of their basal areas. (B.A. sum) in square feet. Species symbols are identified in the earlier footnote.

Species	5 inch class				7 inch class			
	No.		B.A. Sum		No.		B.A. Sum	
	New	Died	New	Died	New	Died	New	Died
Qa	4	13	0.48	1.72	....	9	.....	2.27
Fg	23	24	2.66	2.77	1	11	0.25	2.36
As	94	10	10.6	1.24	4	....	0.87	.....
Co	1	4	0.10	0.58	....	1	.....	0.21
Qr	1	.....	0.09	.....	....	....	.....	.....
Cg	3	11	0.37	1.49	....	4	.....	0.91
Ns	3	7	0.36	0.87	....	1	.....	0.32
Ar	8	4	1.04	0.55	....	4	.....	1.18
Fa	13	7	1.50	0.74	1	1	0.20	0.20
Cl	.....	2	.....	0.21	....	....	.....	.....
Cc	.....	2	.....	0.32	....	....	.....	.....
Ov	6	3	0.59	0.22	....	1	.....	0.20
Cf	13	8	1.30	0.92	....	....	.....	.....
Others	4	6	0.43	0.74	....	1	.....	0.28
Totals	173	101	19.4	12.4	6	33	1.32	7.93

Mortality

At least 15 trees died from windthrow in the 19.6 acres since 1954, when their basal area had totaled 36.6 sq. ft., or nearly 2 sq. ft. per acre. Eight of these were white oaks, ranging in d.b.h. from 5.6 to 37.7 in. and having had 29.0 sq. ft. basal area sum. Three windthrown white oaks had exceeded 30 in. d.b.h. A black oak 27.6 in. was windthrown. The 1954 basal area sum of the 7 recognizably windthrown trees other than white oak was 7.66 sq. ft.

Small trees (Fg 6.2, 6.4 in.; As 4.0; Ar. 5.5; Fp 9.2) killed were seldom directly blown over or broken off, but were borne down by larger windthrown trees or large falling limbs. Figures on mortality by wind were certainly conservative, because windthrow could usually be definitely ascertained only in trees killed fairly late in the decade. Mortality figures are in Tables 1 and 2.

The most striking observation in the field was the surprisingly rapid rate of decay of fallen trees that had been alive and standing in 1954. In several instances, we would have judged that such logs had been lying on the ground for several decades. A prostrate trunk from a tree about 12 in. d.b.h. would usually have been reduced to half its original volume or less. Often little or no sign of a fallen tree of the 6 in. size class remained. The normal annual precipitation of approximately 42 in., and the normal annual temperature mean of 55° F., are high for Indiana.

Use of a bridle trail along the east edge of the study area was begun during the decade. It followed a ridge where tree growth was somewhat more open and a higher proportion of small trees occurred.

Even though no trees were cut for the trail, several small trees died from soil trampling. Nowhere else in the stand was there any disturbance brought about by human activities, since the foot trail (Trail 3) has existed since long before 1954 and has not caused tree mortality recently.

Death of the small trees (Table 1) that had been living in 1954 was generally due to shading and suppression. Data in the table suggest greater shade tolerance for sugar maple than for beech; the latter nearly held its own in the 5-inch class but fell off badly in the next class. White oak of these sizes survived very poorly, and very few new accessions of this species entered these classes. This is probably not entirely due to low tolerance, for a number appeared to be hard hit by the white oak bacterial bark disease.

Table 2 compares deaths within species groups throughout the size-class range. In white oak, mortality accounted for 3.90 sq. ft. basal area per acre. All oak species lost 4.87 sq. ft., all hickories lost 0.82. The combined oak-hickory group had an actual (not net) loss of 5.7 individuals per acre, which had 5.69 sq. ft. per acre of basal area. In contrast, beech and sugar maple combined lost only 2.1 trees per acre with 0.62 sq. ft. per acre. Only one sugar maple over 6 in. d.b.h. died; however, there were very few large sugar maples available.

TABLE 2

Number of individuals lost by death and their actual basal area sums in 19.57 acre stand for all size class of *Quercus alba* (separately) and the species groups *Q. rubra—Q. velutina*, all Carya species, and the Fagus—Acer saccharum group. Last column is for all other species combined.

Size	Qa		Qr, Qv		Co, Cg, Cl, Cc		Fg, As		Others	
Class	No.	B.A.	No.	B.A.	No.	B.A.	No.	B.A.	No.	B.A.
5	13	1.72	....	.....	19	2.60	34	4.01	35	4.17
7	9	2.27	....	.....	5	1.12	11	2.36	8	2.18
9	7	3.06	....	.....	2	0.87	1	0.38	6	2.56
11	1	0.67	1	0.66	2	1.19	2	1.28	7	4.70
13	2	1.95	2	1.72	2	1.76	1	0.86	4	3.58
15	4	5.21	1	1.07	....	.....	....	.....	....	.....
17	2	3.08	1	1.67	....	.....	2	3.34	....	.....
19	....	.....	1	2.07	....	.....	....	.....	....	.....
21	....	.....	....	.....	1	2.36	....	.....	....	.....
23	1	3.08	....	.....	1	3.01	....	.....	....	.....
25	....	.....	....	.....	1	3.19	....	.....	....	.....
27	....	.....	3	11.8	....	.....	....	.....	....	.....
29	2	9.18	....	.....	....	.....	....	.....	....	.....
31	2	10.1	....	.....	....	.....	....	.....	....	.....
33	3	17.4	....	.....	....	.....	....	.....	....	.....
35	1	6.49	....	.....	....	.....	....	.....	....	.....
37	1	7.75	....	.....	....	.....	....	.....	....	.....
47	1	12.25	....	.....	....	.....	....	.....	....	.....
	49	84.2	9	19.0	33	16.1	51	12.2	60	17.2

In summary, 10.3 trees died on the average acre in the 10 year period, representing 7.6 sq. ft. of basal area as of 1954. Subtracting 7.6 from the 121.8 sq. ft. which the 118.6 individuals per acre had in 1954, gives 114.2 sq. ft. per acre represented by the 108 surviving trees.

Gross and Net Growth

Since the above-mentioned 9.1 new trees were included in the 117.3 trees per acre found in 1964, the difference of 108.2 trees had survived from the 1954 population. These survivors had a basal area of 127.3 sq. ft. per acre in 1964. Subtracting from this basal area the 114.2 sq. ft. figure for survivors alone, gives 13.1 sq. ft. for the gross growth increment per average acre. In this gross figure, small new trees (of unknown size in 1954) that entered the 1964 record, and trees dropping out from various size classes by death were not included.

In the above discussion, we have segregated the sources of growth changes. In that to follow, the overall balance will be brought out by restricting consideration to net growth. Tables 3 and 4 include information on net growth; the latter integrates several factors affecting tree numbers and basal area, such as new accessions, increment of wood by trees recorded both at the start and end of the decade, and losses by mortality. Basal area produced since 1954 by trees that died during the decade was disregarded since such trees had not contributed to the biomass of the living forest as of the end of the period of change.

Table 3 shows per cent net gain or loss in density and basal area per acre for each 4 in. size class of all species combined. The average stem diameter increased from 11.4 to 11.8 inches. The overall stand basal area (B_9) showed a 5.4 percent net increment, considering the 1954

TABLE 3

Net changes by size-classes in density per acre (D_2) and basal area per acre (B_2) for the stand, irrespective of species.

Size	Density			Basal Area		
Class	1954	1964	% Change	1954	1964	% Change
6	57.5	52.6	— 8.5	10.3	9.80	— 4.9
10	19.9	22.8	+14.6	10.1	11.6	+14.9
14	11.4	11.9	+ 4.4	11.8	12.5	+ 5.9
18	10.9	9.44	—13.4	19.0	16.7	—12.1
22	7.9	8.33	+ 5.4	21.0	22.0	+ 4.8
26	5.8	6.44	+11.0	21.1	23.3	+10.4
30	3.16	3.83	+21.2	15.1	18.4	+21.8
34	1.23	1.07	.....	7.56	6.79	—10.2
38	0.40	0.56	.....	3.13	4.27	.....
42	0.20	0.20	.....	2.02	1.93	.....
46	0.05	0.10	.....	0.63	1.09	.....
Totals	118.6	117.3	— 1.0	121.8	128.4	+ 5.7

stand as 100. The decrease in density (D_9), which would be expected to accompany an increase in basal area, was less than 1 percent, however. Obviously, the increased basal area was not brought about by net increase in overall tree number, but rather by tree growth, pri-

marily. The same size classes (Table 3) that underwent a net increase in basal area also increased in density. Not only the direction of change is identical for both, but, curiously, the per cent figures compare quite closely within each size class. Exceptions occur in the largest size classes; they contain very few trees and low basal area sums, and show high variability.

Table 4 compares species, instead of size classes as in Table 3, and reveals the dynamics of net change. In the last column of Table 4 is shown the per cent net gain or loss for the basal area of each species over the decade. This indicates great differences in the response of various species over the 10 year interval. Although white oak had the largest number of deaths (Tables 1 and 2) and had very few new trees entering the record in 1964, this species just held its own in basal area (Fig. 1) due to growth of surviving trees. A disproportionate number of these were medium and large. But the net gain in beech and sugar maple, which had very few medium-sized and no large trees, was 19 and 39 per cent (Table 4), because of the many small trees crossing over the 4 in. threshold and the success of these two species in the well-represented small size-classes (Fig. 2). The combined growth of beech and sugar maple shows a B_2 net gain of 26.8 per cent, contrasting with the combined gain of less than 2 per cent for the six species of Quercus and Carya. Species representing neither beech-maple nor oak-hickory type dominants (Table 4) gained 4.6 per cent basal area in 10 years, comparing closely with the 5.4 per cent for the stand as a whole.

Unlike white oak, red and black oaks increased appreciably in basal area (Fig. 1) while holding steady in importance value. Red maple declined in all attributes shown, whereas white ash increased in all.

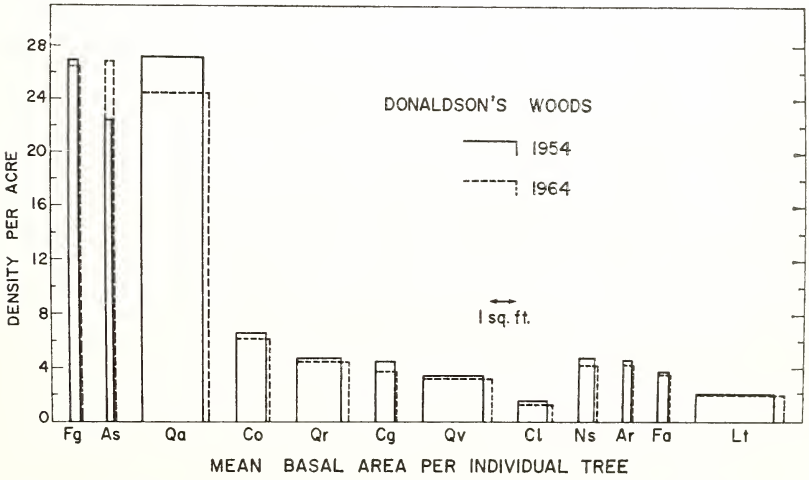


Fig. 1. Comparison of beginning and end of decade by species as to density per acre, basal area per tree, and basal area per acre. The latter, being the product of the other two, is represented by the area of the bar.

TABLE 4

Comparison of species attributes between 1954 and 1964, and percent net gain (+) or loss (−) of basal area (B_2) per acre by species over the decade. Species symbols were identified in the long footnote preceding first table.

Species	Density per acre		Relative Density		Basal Area per acre (B_2)		Relative Basal Area		Importance (V_3)		Percent change in B_2
	1954	1964	1954	1964	1954	1964	1954	1964	1954	1964	
Qa	27.08	24.47	22.8	20.8	62.05	62.32	50.94	48.54	36.9	34.7	+ 0.44
Fg	26.93	26.47	22.7	22.6	9.99	11.92	8.20	9.28	15.4	15.9	+19.3
As	22.53	26.93	18.9	22.9	5.95	8.29	4.88	6.46	11.9	14.7	+39.3
Co	6.59	6.08	5.56	5.18	7.44	7.69	6.11	5.99	5.84	5.58	+ 3.4
Qr	4.75	4.49	4.00	3.83	8.04	8.74	6.60	6.81	5.30	5.32	+ 8.7
Ns	4.70	4.19	3.96	3.57	2.85	2.79	2.34	2.17	3.15	2.87	−21.1
Ar	4.65	4.29	3.92	3.66	1.67	1.57	1.37	1.22	2.64	2.44	− 6.0
Cg	4.55	3.78	3.84	3.22	3.24	3.11	2.66	2.42	3.25	2.82	− 4.0
Fa	3.58	3.78	3.02	3.22	1.68	1.90	1.38	1.48	2.20	2.35	+13.1
Qv	3.42	3.27	2.88	2.79	7.95	8.51	6.53	6.63	4.70	4.71	+ 7.0
Lt	1.94	1.89	1.64	1.61	5.87	6.33	4.82	4.93	3.23	3.27	+ 7.8
Cl	1.58	1.48	1.33	1.26	1.78	1.91	1.46	1.48	1.39	1.37	+ 7.3
Ov	1.53	1.64	1.29	1.40	0.21	0.23	0.17	0.18	0.73	0.79	+ 9.5
Cc	1.33	1.18	1.12	1.00	1.60	1.54	1.31	1.20	1.22	1.10	− 3.8
Cf	1.28	1.53	1.08	1.30	0.13	0.16	0.11	0.12	0.59	0.71	+23.1
Others	2.15	1.84	1.80	1.55	1.35	1.40	1.12	1.10	1.46	1.32	+ 3.7
	D_9				B_9						B_9
	118.6	117.3			121.8	128.4					+5.4

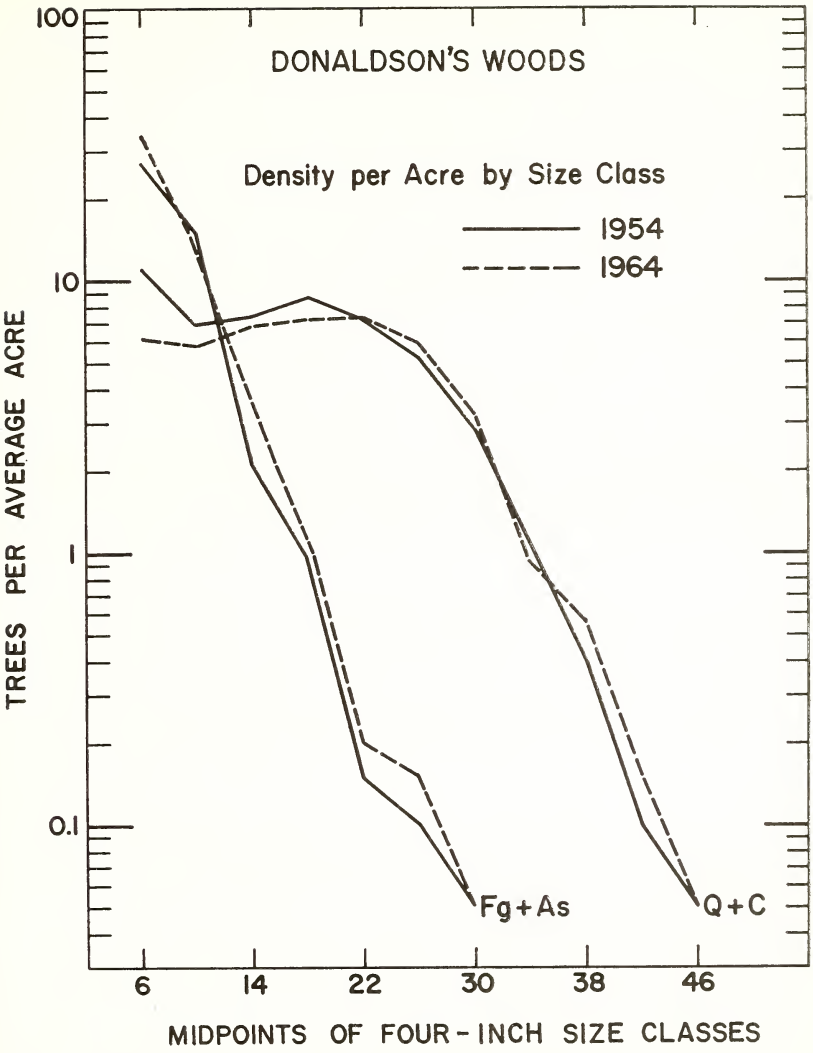


Fig. 2. Semilog plot of tree densities, by four-inch size classes of genera dominance groups in 1954 and 1964. Each line represents either beech and sugar maple combined or oaks and hickories combined, in order to reveal trend of change to a different forest type.

Projected Trend and Discussion

A trend toward a change in species dominance which, if continued, will alter the forest type, is clearly discernible in several ways. Figure 2 brings out this trend by combining the 2 or more dominants of each major forest type of Indiana into a single line, and segregating oak-hickory dominants from the 2 dominant species of the beech-maple type. The crossing of 2 pairs of curves shows that beech and sugar maple dominate in the 6 and 10 in. size-classes, while oaks and hickories dom-

inate the higher size classes. Figure 2 also shows that, during the decade, the combined density of beech and sugar maple increased in nearly all size-classes, while oaks and hickories lost numbers in all classes below 22 in. d.b.h. This clearly suggests a future shift from mixed mesophytic composition to beech-maple.

Beech, and especially sugar maple, far exceed other species in the number of small trees crossing the lower threshold. The same species showed high gross and net growth. Only 4 small white oaks, one red oak, and no oaks of other species, crossed the 4-inch threshold. Three pignut hickories and one shagbark did so. A substantial number of white oak died, especially in the medium and large size-classes, and the net growth of oak-hickory species was lower than that of the beech-maple or the miscellaneous group.

It is evident, then, that the woods is changing from a white oak—beech—maple dominated mixed stand toward a beech—maple type in the distant future, if present trends continue. The latter type is now found (3) in Cox Woods, 14 miles to the south.

A map of presettlement Indiana vegetation (4) shows that Spring Mill State Park lies well within the western mesophytic (Fagus-Quercus-Acer-Carya) forest type of the Mitchell plain. The soil type in Donaldson's Wood is Frederick silt loam (5) a zonal soil of the IV drainage profile. Crankshaw (6) tallied 2,300 bearing trees from early land surveyors records throughout the Frederick silt loam area. He found that the importance value of beech in presettlement days on this soil type was 24.3, white oak 20.5, tulip tree 9.1, all hickories 8.8, sugar maple 8.0, and black oak 6.4. This places the soil type as definitely having supported western mesophytic, as it still does in Donaldson's Woods. Why should it be changing from this to beech-maple? Is the forest change consistent with the climatic situation during the decade?

Climatic data of the U. S. Weather Bureau (7, 8) were examined, both before and after 1954. Paoli, 13 miles away, is the nearest station having a record long enough to give accurate pre-1954 normals for temperature and precipitation. The 55 years of precipitation recorded there averaged 19.4 inches of precipitation for April 1-August 31, whereas this season for the years 1954-1963 averaged 21.2. The 54 years of temperature records averaged 68.3°F over the same 5-month period, but the 1954-1963 mean was 1.2°F, less. Thus, the decade which saw beech-maple increase and oak-hickory decline had climate consistent with this change, i.e., moister and cooler than normal. Records at Bedford (9 mi. from the woods) kept only since 1939 corroborate the difference. The occurrence of such a minor climatic change, even though it went in the direction suitable for beech-maple rather than oak-hickory, does not establish that this actually brought about the observed forest change. Earlier analysis (1) of the 1954 size-class table suggested a marked trend then toward beech-maple which the present study has established for the later period. Although it is tempting to speculate on the significance of the recent vegetation change, this should be more fruitful when data on the stand and the climate for 1964-1974 are at hand.

Literature Cited

1. Lindsey, A. A., J. D. Barton, Jr., and S. R. Miles. 1958. Field efficiencies of forest sampling methods. Ecology **39**:428-444.
2. Schmelz, D. V. and A. A. Lindsey. 1965. Size-class structure of old-growth forests in Indiana. (in press). Forest Science.
3. Schmelz, D. V. 1964. A graphical analysis of the size-class structure of Indiana forests. M.S. thesis, Purdue University.
4. Lindsey, A. A., W. B. Crankshaw, and S. A. Qadir. 1965. Soil relations and distribution map of forests of presettlement Indiana (in press) Botanical Gazette.
5. Tharp, W E., T. M. Bushnell, J. E. Adams, A. T. Wiancko, and S. D. Conner. 1928. Soil Survey of Lawrence County, Indiana. Government Printing Office, Washington.
6. Crankshaw, W. B. 1964. Edaphology of tree species in presettlement Indiana south of the late Wisconsin glacial border. Ph.D. thesis, Purdue University.
7. U. S. Dept. of Commerce. 1958. Climatic Summary of the U. S.—Supplement for 1931-1952. Superintendent of Documents, Washington.
8. U. S. Weather Bureau. 1954-1963. Climatological Data. Superintendent of Documents, Washington.

CHEMISTRY

Chairman: QUENTIN R. PETERSEN, Wabash College

ABSTRACTS

KENNETH COOK, Anderson College, was elected chairman for 1965

The Dissociation of BH_3CO into BH_3 and CO[1]. T. P. FEHLNER and W. S. KOSKI, University of Notre Dame.—The decomposition of BH_3CO has been studied in a low pressure flow system using a special mass spectrometer. The products, determined by using low energy electrons, were found to be BH_3 and CO only. These products were shown to originate in the reactor. As recombination was not a problem at the low reactor pressures, the simple reaction

$$BH_3CO \rightarrow BH_3 + CO$$

was being observed. The calculated first order rate constant, obtained by following the loss of BH_3CO, was found to be independent of the BH_3CO partial pressure, the total pressure, and the surface of the reactor within the experimental range of variables. The mole fraction of BH_3CO ranged from 0.05 to 0.6, while the total pressure was varied from 1 to 20 microns. Three different surfaces were employed. The average rate constant was found to be 19 sec^{-1} at 400°K. Because of the low pressure employed, it was not possible to obtain an activation energy for the reaction from the temperature variation of the rate constant. It was found possible, however, to estimate the activation energy from the determination of the rate constant at 400°K by using the frequency factor for this unimolecular reaction which had been determined in a previous kinetic study. It was found that a good estimate of the activation energy is 23.1 ± 2 kcal/mole. Neglecting the activation energy for the recombination reaction, this gives $D(H_3B\text{-}CO) = 23.1 \pm 2$ kcal/mole. This value when combined with equilibrium data yields $D(H_3B\text{-}BH_3) = 37.1 \pm 4$ kcal/mole.

The Use of Three Disc Electrode Configurations in Electroanalytical Diffusion Coefficient Measurements. JOHN F. ZIMMERMAN, Wabash College.—Chronopotentiometric and chronoamperometric studies have been performed at a shielded gold electrode, a planar unshielded platinum disc, and a similar disc configuration (carbon paste electrode) fashioned from an intimate mixture of carbon and mineral oil. The electrode configurations were studied by examining the Ag(I) reduction in 0.1 *M* KNO_3 the ferrocyanide oxidation in 2 *M* KCl, and 3.3'-dimethoxybenzidene oxidation in 0.5 *M* H_2SO_4. Observations at both unshielded electrodes had to be limited to periods less than sixty seconds. Positive deviations were noted at longer time intervals. This was attributed to the increasing importance of convective interference in the semi-infinite linear diffusions (SILD) mode of mass transport. The SILD approximation was valid for twenty minutes at the shielded electrode. The "break potential" method of analyzing the chronopotentiometric wave was found to be the method of analysis in best agreement with the chronoamperometric data.

---

[1]Research done at the Chemistry Department of The Johns Hopkins University, Baltimore, Maryland.

Reaction of Decachloropentacyclo ($5.3.0.0^{2,6}.0^{3,9}.0^{4,8}$) decan-5-one and Some Derivatives. E. T. McBEE, T. B. WIELICZKO and C. J. MORTON, Purdue University.—This work represents the first reported example of the linking of two decachloropentacyclodecae units. The reaction of decachloropentacyclo ($5.3.0.0^{2,6}.0^{3,9}.0^{4,8}$) decan-5-one with methylmagnesium iodide gave 5-methyl-1,2,3,4,6,7,8,9,10,10-decachloro ($5.3.0.0^{2,6}.0^{3,9}.0^{4,8}$) 5-decanol. This did not react with phosphorus pentachloride but with thionyl chloride gave a compound whose structure consisted of two decachloropentacyclodecane units linked by a sulfite bridge. The mechanism of this reaction is discussed.

Resonance Transfer of Excitation in Viscous Media. RICHARD J. POVINELLI, PETER K. LUDWIG and MILTON BURTON, University of Notre Dame.—Quenching of fluorescence (excited in this work by 3030A uv light) of *m*-terphenyl (*m*-TP) by 9, 10-diphenylanthracene (DPA) and 9, 10-dibromoanthracene (DBA) respectively in benzene-paraffin oil solutions, studied as a function of viscosity, gives information about the relative importance of collisional and resonance energy transfer. The choice of system is based on the fluorescence decay times and the overlap characteristics of the emission spectrum of *m*-terphenyl and the absorption spectra of the anthracene derivatives acting as quenchers. For the systems *m*-TP/DBA and *m*-TP/DPA, theoretical critical transfer distances R_0 of 27.9A and 29.9A respectively were found. The corresponding experimental values are 37.4A and 40.3A. From Stern-Volmer plots, quenching constants γ were determined and compared to those obtained with CCl_4 as quencher. (Presumably, with CCl_4 as quencher, collisional quenching alone occurs.) γ values vary between 289 and 185 M^{-1} for *m*-TP/DBA and 320 to 235 M^{-1} for *m*-TP/DPA in the viscosity range 0.606 to 22.3 cp. For *m*-TP/CCl_4 γ values are 14.6 M^{-1} (viscosity = 0.606 cp) and 4.5 M^{-1} (viscosity = 12.1 cp). The differences in the two sets of γ values point up the differences in mechanism of excitation transfer.

Luminescence Phenomena at 77°K and 90°K. MICHEL A. DILLON, PATRICK J. HERLEY and MILTON BURTON, University of Notre Dame.—Luminescence of long duration in pure 3-methylpentane glass at 77°K consequent to irradiation by ^{60}Co γ rays has been previously reported from this Laboratory. As a matter of convenience, new work has been performed additionally with 2-methylpentane. The wavelength of light emission extends over about 1500A with $\lambda_{max} \approx$ 4250A as determined by rapid scan spectrophotometry. The new observations here reported relate exclusively to light emission in the range 4200 - 4300A. As in previously reported work, the isothermal decay (i.e., the very fast decay portion) of the light emission was found to obey an equation represented by a sum of three exponentials with lifetimes of order of 500 sec but the faster decay constants differ markedly from those previously reported. Values of activation energies were obtained from isothermal decay curves on samples irradiated and permitted to decay at 77°K and 90°K respectively. The activation energy *so determined* for both 2- and 3-methylpentane now appears to be 0.03 ev for all such portions. The entropy of activation for the fast portion of 3-

methylpentane is now estimated to be 46 e. u. Decay is accelerated by continuous irradiation with light of $\lambda > 7000$; as in the dark experiments, the decay curve breaks into three portions but the rate constants (particularly the initial one) are significantly increased without any apparent effect on E_a or $\Delta S^{\ddagger}$. The observed phenomena are explained in terms of an electron-hole recombination model with the charge separation being the result of the initial energy deposition.

Radiolysis of Benzene and Benzene-Cyclohexane Mixtures in the Presence of Nickel Tetracarbonyl. HELMUT F. BARZYNSKI, ROBERT R. HENTZ, and MILTON BURTON.—*G* values of hydrogen and biphenyl formation in γ irradiated mixtures of benzene and nickel tetracarbonyl show that some excited benzene species are protected against decomposition by nickel tetracarbonyl. It is argued that two kinds of primary process contribute to the hydrogen yield: (1) a rapid unimolecular elimination of molecular hydrogen that is not quenched by carbonyl; (2) a process giving a second-order hydrogen yield that is associated with biphenyl formation and is quenched by carbonyl. Yields were determined for the major radiolysis products from benzene-cyclohexane mixtures containing nickel tetracarbonyl at fixed electron fraction (ε 0.68) at different electron fractions of each hydrocarbon in the range ε 0 to 0.32. At ε (nickel tetracarbonyl) 0.68 most of the cyclohexane decomposition is inhibited; the residual decomposition of the cyclohexane is to a major extent by rearrangement to ultimate molecules and to a minor extent by rupture into free radicals and atoms. These residual decomposition processes are not appreciably quenched by further addition of either protective agent. The suppression of products by benzene, in this case, represents actual scavenging of free radicals and atoms.

[1]The Radiation Laboratory is operated under contract with the Atomic Energy Commission. This is AEC Document number COO-38-370.

Generation and Measurement of Uv Light Pulse in the Nanosecond and Sub-nanosecond Region

Peter Ludwig, Juan D'Allessio and Milton Burton,
University of Notre Dame

Uv light pulses of duration of 10^{-9} seconds or less are an important tool in the study of very fast photochemical processes. Hitherto, lamps possessing the required characteristics did not exist. The best available lamps suffered from after-pulses of high firing voltages, were erratic in operation and actually had characteristic times much exceeding the nanosecond requirement.

A lamp has now been developed which produces a uv pulse of a desirable shape, namely a half-width of 0.4 nsec and rise and decay times of 0.3 nsec and 0.5 nsec respectively measured between 10% and 90% full intensity. The light output is estimated to be about 10^6 photons per 0.003 steradian. These light pulse characteristics are obtained with a high pressure (20atm) hydrogen lamp with specially shaped fixed electrodes which are kept covered with a mercury film during operation; cf. Figure 1. To achieve these desirable pulse characteristics the lamp and associated electrical elements must be coaxially mounted.

For measurement of the shape of the light pulse, an electronic sampling technique is used because common light-to-electric current converters have too small a band width to permit undistorted conversion. The main component of the sampling equipment is an image converter which permits measurement of the average light intensity of a large number of light pulses in the very narrow time intervals at preset points on the light pulse curve.[1,2] The light pulse curve is easily constructed from such average values. The requirement of precise timing of the detection system and the light pulses is met by use of of the electric pulse in the lamp as a trigger for the detection system. Incidentally, the electric pulse itself has characteristics which approximate in form the light pulse curve. In convenient operation, the electric pulse output is 1200 volts maximum. Because the delay in the electric pulse control circuit is less than the delay experienced by the electrons in the image converter, it is actually possible to use the electric pulse to trigger observation before the light signal reaches the critical parts of the image converter; cf. Figure 2.

The principal utility of a lamp of the type described is in studies of the behavior of directly excited states. In radiation chemistry, energy ultimately localized in a small-concentration solute has been originally deposited in a system which, in toto, greatly exceeds in quantity the relatively few molecules under direct study. One consequence is that interpretation of the kinetic behavior is obfuscated by a number of unknown factors. Direct excitation of a solute (by light which can affect only that solute directly) can be studied, so far as

1. The Radiation Laboratory is operated under contract with the Atomic Energy Commission. This is AEC Document number COO-38-372.

immediate effects are concerned, in terms of the luminescence behavior of that solute if it is properly chosen. Because of the intensity of the lamp herein described, it is quite reasonable to select only the limited light which can affect only the solute, and not the solvent, if it be properly chosen. A combination of filters properly selected can ensure that the fluorescence of the single species under study is the only one which can affect the apparatus used for observation of decay times of that fluorescence. Some rough, but significant, preliminary experiments have been performed.

Literature Cited

1. Dreeskamp, H., and M. Burton. 1959. Phys. Rev. Letters, 2, 45.
2. Ghosh, A., and M. Burton. 1961. Rev. Sci. Instr. **32**:304.

The Preparation of Several 3,4-Dialkylquinolines and Intermediate Compounds

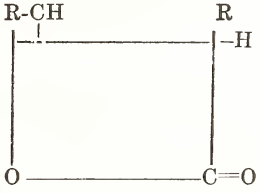
D. J. Cook and Wayne E. Schelwalt,[1] DePauw University

Past studies have shown the use of diketene for the preparation of a number of substituted carbostyrils from aniline and the subsequent reduction of the carbostyrils to the corresponding quinolines. (1) (2) The present study involved the preparation of several alkylketene dimers which were then condensed with aniline to give the substituted acetoacetanilides and then converted to the 3, 4-dialkylcarbostyrils by an acid catalyzed ring closure. The various ketene dimers were prepared by the dehyrohalogenation of the corresponding acid chlorides.

$$RCH_2COCl + (C_2H_5)_3N \xrightarrow[\text{ether}]{\text{anhyd.}} (RCH{=}C{=}O) + (C_2H_5)_3N.HCl$$

$$2(RCH{=}C{=}O) \longrightarrow RCH_2CORC{=}C{=}O$$

The ketenes dimerize spontaneously on heating without isolation of the monomer. The accepted structure of the ketene dimers is the cyclic lactne.



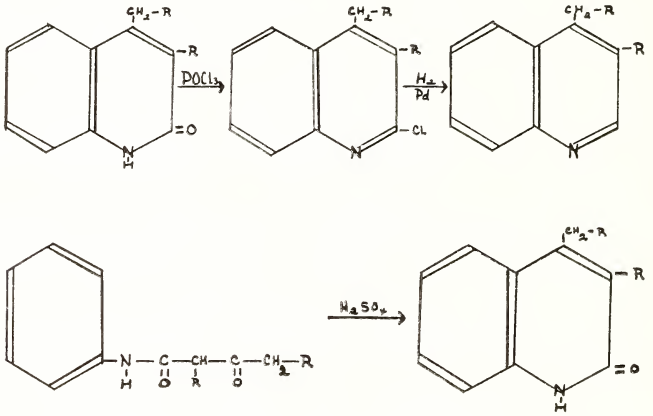
The alkylketene dimers were prepared according to the method of Sauer (3) and are listed in Table 1.

The ketene dimers were condensed with equimolar quantities of aniline by dropwise addition of the dimer to the amine at a temperature of 110°C and subsequent heating of the mixture for three to four hours at a temperature of 130°C. The resulting α, ν-dialkylacetoacetanilides were purified by recrystallization from ethanol as white crystalline solids. They are listed in Table 2.

Ring closure of the substituted acetoacetanilides was completed by the method of Knorr (4). While acetoacetanilide ring closes under exothermic conditions, the substituted acetoacetanilides were much slower. Various amounts of sulfuric acid were employed and it was found that a four to one ratio of sulfuric acid to the substituted acetoacetanilide by weight gave the best results. With an increasing carbon chain length of the substituted acetoacetanilide side chains, ring closure was found to proceed best when the temperature of the reaction mixture was held lower than 85°C for α-propionlypropionanilide and no higher than 65°C for the higher chain length anilides.

[1]Submitted to the Chemistry Department of DePauw Univrsity as a partial fulfillment of the Master of Arts Degree by Wayne E. Schelwalt, June, 1964.

Higher temperatures reduced the yield of the carbostyrils by 15-30%. The time of reaction varied from 15-20 minutes for the two smaller members of the series to 30-60 minutes for the two larger substituted acetoacetanilides. The 3, 4-dialkylcarbostyrils have the following general formula and are reported in Table 3.



By means of previous described methods (2) (5), the carbostyrils were converted to the 2-chloro-3, 4,-dialkylquinolines and then reduced to the quinolines.

The carbostyrils were heated with a slight excess of phosphorus oxychloride at 85°C for approximately thirty minutes and the excess $POCl_3$ was destroyed in ice water. The 2-chloro-3, 4-dialkylquinolines were then recovered by extraction with ether, dried, and the other removed leaving oils. The two lower homologs of the series were crystallized from ethanol but the two higher members of the series could not be purified by crystallization nor could they be distilled without decomposition. These oils were again extracted with ether and dried. Upon evaporation of the ether, the oils were recovered. Although no physical constants were obtained, the oils were sufficiently pure for analysis. These compounds are listed in Table 4.

Although a variety of methods have been described for the reduction of 2-chloroquinolines to the quinolines (6) (2), palladium on carbon with low pressure hydrogenation was used to prepare the 3, 4-dialkylquinolines in this study. The time necessary to reduce these chloroderivatives to the quinoline was much longer than that required for 2-chlorolepidine. The 2-chloro-3, 4,-dialyklquinolines required a minimum of fifteen to twenty hours at pressures of thirty to thirty-five pounds. The quinolines prepared in this study are listed in Table 5.

The picrates of the substituted quinolines listed in Table 5 were prepared by the accepted method and identified. These compounds are listed in Table 6.

The principal infrared absorption spectra of these compounds have been summarized in Table 7. The absorption bands of each class of compounds are quite similar from one compound to the other. The

TABLE 1

Ketene Dimer	Percent Yield	b.p. °C	Reported b.p.°C (3)
R = CH_3	38	45-48/10 mm	57-58/12 mm
C_2H_5	66	74-75/11 mm	95-96/32 mm
C_3H_7	66	97-98/10 mm	135-36/30 mm
C_4H_9	40	121-22/ 8 mm	127-29/ mm

TABLE 2

Substituted Acetoacetanilides	Percent Yield	m.p. °C.	Reported (3) m.p. °C
α-Propionylpropionanilide	77	118.5-119	——
α-Butryrylbutyranilide	85	84-85	84-85
α-Valerylvaleranilide	84	88-89	68-69
α-Caproylcaproanilide	83	84-85	76-77

TABLE 3

Carbostyril	m.p. °C	Percent Yield	Analysis Found C	H	N	Analysis Calculated C	H	N	Picrate m.p. °C
R = CH_3	188.5-190	84	77.0	6.96	7.56	77.0	6.95	7.48	186-187.5
C_2H_5	186-187	88	77.3	7.81	6.66	78.3	7.91	6.52	151-152
C_3H_7	142	31	78.1	8.38	6.19	79.2	8.65	5.77	146-147
C_4H_9	148-149	56	78.7	9.50	5.32	79.7	9.24	5.17	120-121

TABLE 4

2-Chloro-3, 4-dialkylquinolines	Percent Yield	m. p.°C	Analysis Found C	H	N	Analysis Calculated C	H	N
R = CH_3	90	71.5-72.5	70.0	5.99	6.75	70.2	5.85	6.82
C_2H_5	100	87.5-88.5	71.8	6.78	5.97	72.0	6.85	6.00
C_3H_7	81	oil	73.5	7.50	5.85	73.5	7.65	5.36
C_4H_9	100	oil	74.2	8.22	4.98	74.7	8.28	4.84

TABLE 5

Substituted Quinoline	Percent Yield	b.p. °C	N, Found	N, Calcd.
3-Methyl-4-ethyl- (I)	36%	154-156/10 mm	6.37	8.18
3-Ethyl-4-n-propyl (II)	40%	167-169/10 mm	7.25	7.04
3-n-Propyl-4-n-butyl (III)	63%	186-190/10 mm	6.37	6.17
3-n-Butyl-4-n-pentyl (IV)	61%	215-218/8.5 mm	5.49	5.78

TABLE 6

		Analysis Found			Analysis Calcd.		
Picrate of	m.p. °C	C	H	N	C	H	N
I	190-192	53.6	3.78	13.69	54.0	4.00	14.0
II	172-173	56.3	4.88	12.93	56.1	4.67	13.1
III	166-167	57.5	5.14	12.2	57.9	5.26	12.2
IV	137-139	59.8	6.06	11.5	59.5	5.78	11.6

TABLE 7
Infrared Spectra

Compound	Alkane CH (mull)	Aromatic CH (mull)	Lactam $1640cm^{-1}$	C=C and C=N	Hydrogen Deformation
3, 4-Dialkyl-carbostyril				$1550\ cm^{-1}$ 1600 1500 1450	$745\text{-}755\ cm^{-1}$
2-Chloro-3, 4-dialkylquinoline	$2850\text{-}2925cm^{-1}$	$3050\ cm^{-1}$	none	$1550\text{-}1560cm^{-1}$ 1600 1500 1450	$760\ cm^{-1}$
3, 4-Dialkyl-quinoline	$2850\text{-}2925cm^{-1}$	$3050\ cm^{-1}$	none	$1640\text{-}1650\ cm^{-1}$ 1550-1560 1600 1500 1450	$760\ cm^{-1}$

spectra of the carbostyrils are closely related to those already reported (7). Although a limited amount of data has been reported concerning the quinolines (8), agreement has been found between these compounds and the less highly substituted quinolines. However, where 2, 3- and 2, 4-dimethylquinoline show bands at 755-758 cm^{-1} for the four adjacent hydrogen in the homocyclic ring and a band at 864 cm^{-1} for the single heterocyclic hydrogen atom (9), it is of interest to note that the 3, 4-dialyklquinolines prepared in this study, show only a strong hydrogen deformation band near 760 cm^{-1} with no band appearing in the 860-900 cm^{-1} region which should be due to the single hydrogen in the 2 position of the hetero ring. In both types of compounds, 2-chloro-3,4-dialkylquinoline and 3,4-dialkylquinoline, there are common absorption bands at 922, 1060, 1162 and 1300 cm^{-1} but which have not been identified.

Experimental[2]

Since each class of compounds were prepared by similar methods, only one illustration of each type will be described. The ketene dimers were prepared according to the method described by Sauer (3).

α-Propionylpropionanilide. Twenty-five grams (.268 moles) of aniline was heated to 110°C and 30 g. (.268 moles) of methylketene dimer was added dropwise with stirring over a period of thirty minutes. The mixture was then maintained at 130° for another three and one-half hours. After cooling, the mixture was dissolved in a small amount of alcohol and with the addition of water, light tan crystals formed. The weight of the product was 42.7 g. and melted at 118.5-119°C.

Anal. Calcd. for $C_{12}H_{15}NO_2$: C, 70.3; H, 7.78; N, 6.88
Found: C, 70.4; H, 7.60; N, 7.77.

Other compounds of this series are reported in Table 2.

3-Methyl-4-ethylcarbostyril. Fifty-nine grams of concentrated sulfuric acid was heated to 75°C and over a twenty to thirty minute period, 14.7 g. (.0714 mole) of α-propionylproponanilide was added to the acid with stirring. The reaction mixture was then heated to 85° for ten minutes and then poured into 600 ml of ice water and neutralized with aqueous sodium hydroxide. The crude product was recrystallized from ethanol and water. The yield was 11.2 g. and melted at 188.5-190°C. Details of these products are noted in Table 3.

2-Chloro-3-methyl-4-ethylquinoline. Nine and nine-tenth grams of 3-methyl-4-ethylcarbostyril (.0529 moles) was heated in 9.73 g. (.0634 moles) of phosphorus oxychloride at 80-85° for fifteen minutes. The hot solution was poured into 400 ml. of ice water and the precipitate extracted with ether and dried over anhydrous sodium sulfate. After removal of the ether, the product was recrystalized from ethanol and water. The product weighed 9.7 g. and melted at 71.5-72.5° C. These compounds are listed in Table 4.

3-Methyl-4-ethylquinoline. Eight grams (.0389 moles) of 2-chloro-3-methyl-4-ethylquinoline and 3.19 g. of anhydrous sodium acetate was dissolved in 100 ml of glacial acetic acid. Three grams of palladium on carbon catalyst was added to the solution and the mixture subjected to

[2]All melting points and boiling points are uncorrected.

low pressure hydrogenation (30 pounds) at a temperature of 55-70°C for sixteen hours. The catalyst was removed by filtration and the acetic acid separated by vacuum evaporation at 70°C and 25 mm. The residue was poured into water and neutralized with sodium hydroxide. The aqueous suspension was extracted with ether, dried over anyhdrous sodium sulfate, and the ether removed. The oil was distilled and 2.4 g. which boiled at 154-156°/10 mm was recovered. The product is a colorless, oily liquid with no distinct odor. Data concerning the prepared 3, 4-dialkylquinolines are found in Table 5 and the corresponding picrates are reported in Table 6.

Literature Cited

1. Cook, D. J., and W. C. Lawall, 1948. J. Am. Chem. Soc. **70**:1918.
2. Horning, E.1955. Organic Syntheses. John Wiley and Sons, Inc., New York. Col. Vol. III: 194 and 519.
3. Sauer, J. C. 1947. J. Am. Chem. Soc. **69**:2444.
4. Knoor, L. 1886. Ann. **236**:110.
5. Mikhalov, G. I. 1936. J. Gen. Chem. U.S.S.R. 6:511, cited in C.A. 30:6372, (1936).
6. Krahler, S. E. and A. Burger. 1941. J. Am. Chem. Soc. **63**:2368.
7. Cook, D. J., R. S. Yunghans, T. R. Moore, and B. E. Hoogenboom. 1957. J. Org. Chem. **22**:211.
8. Bellamy, L. J. 1954. Infra-red Spectra of Complex Molecules. John Wiley and Sons, Inc. New York. 279.
9. Cook, G. L., and F. M. Church. 1957. J. Phys. Chem. **61**:458.

Some Problems Encountered in Copolymerization Studies Using Ziegler-Natta Type Catalysts[1]

T. C. SCHWAN, Valparaiso University

INTRODUCTION

It was hoped to obtain copolymerization parameters for a series of copolymers obtained by initiation with Ziegler-Natta catalysts. Preliminary experimentation restricted the list of monomers to just the styrene-acryonitrile pair. Vinyl acetate was found to enter into copolymerization with styrene in only trace amounts, methyl acrylate produced a tacky semi-solid which proved impossible to handle; other monomers such as ethyl vinyl ether and allyl chloride were eliminated because of vigorous reaction with catalyst components.

Preliminary copolymerization of styrene and acrylonitrile with a TIBAL-$VOCl_3$ catalyst system indicated, Fig. 1, the following reac-

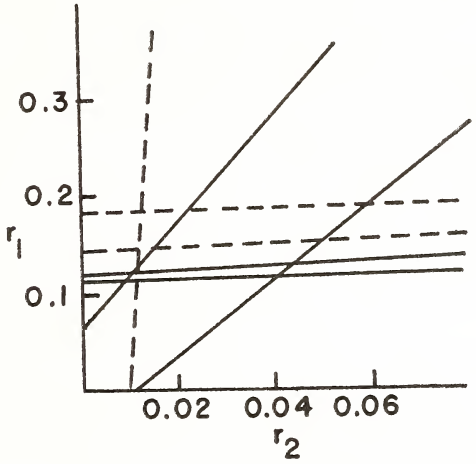


Figure 1. Copolymerization: Styrene (M_1) and Acrylonitrile (Preliminary Data)

Carbon Analysis: ————

Nitrogen Analysis: - - - -

[1]Acknowledgment is made to the donors of the Petroleum Research Fund, administered by the American Chemical Society, for support of this research, to Dr. H. N. Friedlander and Dr. G. F. D'Alelio for advice and encouragement in various stages of the work, and to American Chemical Society-Petroleum Research Fund Scholars Bette J. Gahl, Judith K. Lense, Russell H. Nord and Roger F. Vogel.

tivity ratios: (styrene = M_1) : $r_1 = 0.12 \pm 0.01$, $r_2 = 0.03 \pm 0.02$. It was decided then, to study the copolymerization of this monomer pair in greater detail, to compare results at different temperatures and with another catalyst system.

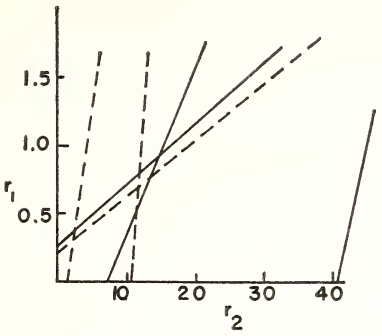
Experimental Methods

Monomers and solvents were purified in the usual way with special precautions to exclude oxygen and water at all times. TIBAL was transferred under nitrogen in a polyethylene glove bag to amber bottles stoppered with perforated, Buma S rubber-lined crown caps. Otherwise, TIBAL was used as received in a 25% solution in hexane. Vanadium oxytrichloride was distilled under nitrogen at atmospheric pressure in all-glass apparatus, and diluted under nitrogen in a polyethylene glove bag with cyclohexane to a 25% solution. The solution was stored in an amber bottle fitted with a three-way stopcock to permit removal with a syringe under a flow of nitrogen. Titanium trichloride was weighed under nitrogen in the glove bag into glass stoppered weighing bottles which were stored in a desiccator under nitrogen.

Copolymerizations were carried out in 3-neck, glass joint, 100 ml., flat bottom flasks equipped with a thermometer, condenser, three-way stopcock and magnetic stirring bar. The apparatus was oven dried, assembled, flushed with nitrogen for at least one hour and charged by use of syringes through the 3-way stopcock under a constant flow of nitrogen entering the system through one arm of the stopcock. The open end of the condenser was protected from the atmosphere with a dibutyl phthalate seal-bubbler. The $TiCl_3$ was dumped into the flask through an open neck shielded from the atmosphere with a large funnel through which nitrogen was passed rapidly.

The order of addition of reagents and a typical recipe are given in Table 1. Monomers were mixed and flushed with nitrogen before addition to the flask. Reactions were carried out at two temperatures: (1) 0° to 5° C. was maintained through the initial vigorous reaction of monomer with catalyst and for several hours thereafter by immersing the flask in an ice bath, then the temperature was allowed to reach room temperature; and (2) the contents of the flask, before addition of monomers, were heated to 72° C. with the addition of monomers raising the temperature to 80° C. or to a lower reflux temperature which was maintained throughout the reaction.

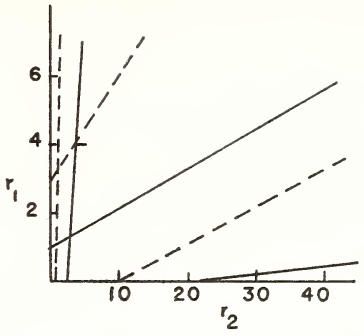
After sixteen to eighteen hours, the reaction was quenched by pouring the contents of the flask into methanol containing 1.5% of hydrogen chloride (45 ml. of concentrated HCl in 1 liter of methanol). The copolymer was filtered off on sintered glass crucibles and redissolved in an appropriate mixture of solvents selected from benzene, N,N-dimethylformamide, tetralin and butyrolactone. Great difficulty was experienced repeatedly in dissolving completely the copolymers even though many different mixtures of the above solvents were attempted. In several instances, a reprecipitated copolymer would not dissolve in a solvent mixture previously found satisfactory for that particular sample. After redissolving, the copolymer was reprecipitated in acidified methanol in a Waring blender to avoid formation of a



a. Catalyst: TIBAL-$VOCl_3$

Temperature: 0°C.

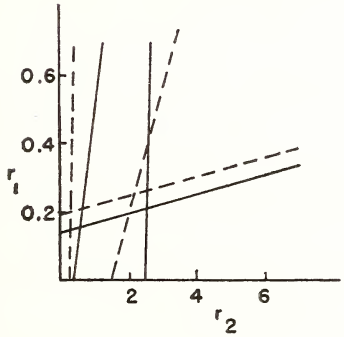
r_1=0.7; r_2=12



b. Catalyst: TIBAL-$VOCl_3$

Temperature: 80°C.

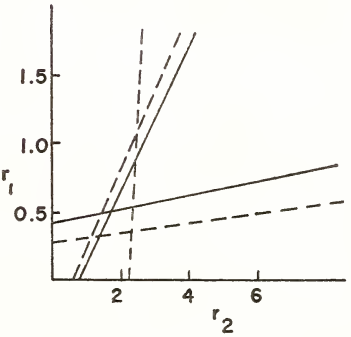
r_1=2; r_2=5



c. Catalyst: TIBAL-$TiCl_3$

Temperature: 0°C.

r_1=0.2; r_2=1.5



d. Catalyst: TIBAL-$TiCl_3$

Temperature: 80°C.

r_1=0.5; r_2=2

Figure 2. Copolymerization: Styrene (M_1) and Acrylonitrile (M_2).

Carbon Analysis ————; Nitrogen Analysis – – – – –

ropey precipitate which would trap solvent and catalyst residues. Copolymers were reprecipitated at least six times with the final copolymer solution also filtered through a sintered glass crucible. The copolymer finally was washed with methanol and pentane and dried in a vacuum oven at 80° C. to give a friable material of light tan color. Catalyst and monomer ratios and analytical data are summarized in Table 2.

Table 1. Typical Copolymerization Recipe

Reagent	Milli-moles	Quantity measured	Mole fraction
Cyclohexane	92.6	10 ml.	0.593[a]
TIBAL (25% in hexane solution)	22.5	24.5 ml.	0.028
$VOCl_3$ (25% in cyclosexane solution	7.5	5.7 ml.	0.009
Cyclohexane	185	20 ml.	——
Styrene	150	15.6 g.[b]	0.185
Acrylonitrile	150	7.96 g.[b]	0.185

[a]Reported here as 0.593 mole fraction of total diluents.

[b]Weighed to nearest 0.01 g., mixed together and flushed with nitrogen before adding to the reaction flask.

Table 2. Copolymerization of Styrene (M_1) with Acrylonitrile

Catalyst[a]	Temp.	M_1	%C	%H	%N	M_1 (C)[b]	M_1 (N)[c]
$VOCl_3$	0°C.	0.895	85.46	7.60	5.73	0.768	0.744
$VOCl_3$	0°C.	0.501	65.96	6.34	15.69	0.107	0.296
$VOCl_3$	0°C.	0.100	62.89	6.39	22.04	0.0027	0.010
$VOCl_3$	80°C.	0.900	89.55	7.90	0.81	0.905	0.964
$VOCl_3$	80°C.	0.502	63.94	6.43	20.47	0.038	0.082
$VOCl_3$	80°C.	0.104	64.09	6.77	19.06	0.043	0.145
$TiCl_3$	0°C.	0.897	81.62	7.62	5.25	0.683	0.714
$TiCl_3$	0°C.	0.512	72.69	7.05	12.97	0.416	0.295
$TiCl_3$	0°C.	0.100	60.14	6.84	14.70	0.042	0.200
$TiCl_3$	80°C.	0.914	87.03	7.86	3.79	0.845	0.794
$TiCl_3$	80°C.	0.499	70.55	7.15	11.52	0.352	0.373
$TiCl_3$	80°C.	0.101	57.91	7.33	17.51	——	0.046

[a]Catalyst was TIBAL plus $VOCl_3$ or $TiCl_3$ as indicated.

[b]Mole fraction of styrene in the copolymer as calculated from carbon content.

[c]Mole fraction of styrene in the copolymer as calculated from nitrogen content.

Table 3 Elemental Analysis of Polyacrylonitrile

Catalyst	%C	%H	%N	%Cl	%0	% ash
TIBAL-$VOCl_3$	62.81	6.27	22.30	——	——	0.63
TIBAL-$TiCl_3$	59.32	6.95	17.59	——	——	0.09
TIBAL-$TiCl_3$*	58.17	63.0	19.18	——	——	0.09
(Theory	67.90	5.70	26.40)			

*Repeat analysis of the preceding sample.

In determining mole fractions of monomers in the copolymers, percentage composition obtained from elemental analysis of polyacrylonitrile (Table 3) was used rather than theoretical percentage. Figure 2 shows the plots obtained from the data by the "intersection method" of Mayo and Lewis (1). Accepted r_1, r_2 values for styrene and acrylonitrile by free-radical polymerization are $r_1=0.41$, $r_2=0.04$ (2), and by anionic copolymerization, $r_1=0.20$, $r_2=11\text{-}14$ (3). Reactivity ratios obtained in this work as approximated in Figure 2, lie generally between the values for free-radical and anionic copolymerization possibly indicating simultaneous copolymerization by both methods (4).

Further complicating the picture is the indication of homopolymerization possibly taking place. A small portion of the copolymer was usually found to be soluble in benzene. One copolymer sample gave a nitrogen content of 11.6% whereas the benzene-insoluble fraction after solvent fractionation contaied 13.07% nitrogen.

Summary

The work has raised more questions than it answered. Reactivity ratios for the styrene (M_1) acrylonitrile monomer pair appear to be for TIBAL- $VOCl_3$ at 0° C., $r_1=0.7$ and $R_2=12$, for TIBAL-$VOCl_3$ at 80°C, $r_1=2$ and $r_2=5$ for TIBAL-$TiCl_3$ at 0°C, $r_1=0.2$ and $r_2=1.5$ and for TIBAL-$TiCl_3$ at 80°, $r_1=0.5$ and $r_2=2$. Plots for the solution of these reactvity ratios give approximations only. Discrepancies and nonreproductibility may be caused by any combination of the following factors: faulty technique and procedure, excessive homopolymerization, block copolymerization, and simultaneous copolymerization by free-radical and anionic mechanism. Further study should include the nature of the reactions by which ogygen and chlorine are introduced into the copolymer.

Literature Cited

1. Mayo, F. R., and F. M. Lewis. 1944. J. Am. Chem. Soc.: **66**:
2. Alfrey, T. Jr., J. J. Bohrer and H. Mark. 1952. "Copolymerization" Interscience Pub. Inc., N. Y.
3. Zutty, N. L. and F. J. Welch, 1960. J. Polymer Sci. **43**:445-452.
4. O'Driscoll, K. F. and A. V. Tobolsky. 1959. ibid., **37**:363.

ENTOMOLOGY

Chairman: MERRILL L. CLEVELAND, USDA, ARS, ERD, Vincennes
GERTRUDE L. WARD, Earlham College, was elected chairman for 1965

ABSTRACTS

The Alfalfa Weevil, Hypera postica (Gyll.) a New Economic Pest of Alfalfa in Indiana. RALPH A. BRAM, Purdue University.—Larvae of the alfalfa weevil, *Hypera postica*, were collected for the first time in Indiana on May 13, 1964 near Vincennes, Knox County. Subsequently, adults of this major economic pest of alfalfa were discovered in nine other counties in the southern quarter of the state, including Vanderburgh, Gibson, Spencer, Perry, Warrick, Dubois, Harrison, Jefferson, and Switzerland counties. In each instance there was no evidence of economic damage and specimens were present in only trace numbers. Experience in other states in which the alfalfa weevil has been newly introduced indicates that economic damage may be expected approximately two years after trace numbers are first discovered.

Color Pattern Inheritance in Experimental Hybrids or North and South American Forms of Tropisternus collaris (Fabricus) (Coleoptera: Hydrophilidae). FRANK N. YOUNG, Indiana University.—Crosses of a melanic form of *Tropisternus collaris* (Fabricius) from Colombia with typical *T. mexicanus mexicanus* (Castelnau) and *T. m. striolatus* (LeConte) from Indiana indicate the specific identity of these putative species. Both the *mexicanus* and *striolatus* pronotal and elytral patterns show dominance over the melanic *collaris* pattern with penetrance of over 85%. The exceptions are thought to be due to modifier genes. F_1 Hybrids are highly sterile, but backcrosses show nearly normal fertility. Both F_1 hybrids and backcrosses show indications of hybrid vigor or enhancement.

Effect of Photoperiod upon Rate of Development in Naiads of Erythemis simplicicollis (Say) (Odonata; Libellulidae). B. ELWOOD MONTGOMERY and JERRY M. MACKLIN, Purdue University.—Almost all naiads of *E. simplicicollis* (Say) collected in the middle instars (octult to sextult) late in October survived to emergence as adults when reared in an environment with constant photoperiods. The final three instars required about 80 days at 27°C., and 91 days at 21° with a photoperiod of 16 hours, with about half this time in the ultimate instar; these times were 211 days at 27° and 238 days at 21°, respectively, with a photoperiod of nine hours, with about half this time in the teritult instar. Very few naiads of the same species collected in August survived to emergence under the same conditions. With a photoperiod of nine hours only five per cent survived to the final instar, and 90 per cent died before passing through more than two instars; with longer photoperiods the survival rate was higher, but no lots showed a survival rate (to the ultimate instar) greater than 65 per cent.

Notes on the Biology of Psorophora ciliata (Fabricius) in Indiana. R. E. SIVERLY, Ball State College.—Presumably the largest mosquito

found in Indiana, *Psorophora ciliata* (Fabricius) is produced in exposed pools of a temporary nature, following summer rains. As many as ten larvae of *Aedes vexans* may be eaten by one *P. ciliata* larva in one day. There are several broods a season. At prevailing temperatures in Indiana during July and August, egg to adult development may be completed in one week. In spite of its predaceous habit and rapid development, *P. ciliata* is of doubtful economic importance in natural control, because of its cannibalistic tendencies and the extreme dominance of *Aedes vexans*, which usually occupies the same type habitat.

Occurrence of Psorophora discolor (Coquillett) in Indiana. R. E. SIVERLY and RICHARD W. BURKHARDT, JR., Ball State College.—Larvae of *Psorophora discolor* (Coquillett) were taken in a roadside ditch in Delaware County in July, 1964. Adults of this species of mosquito are similar in appearance to *Psorophora confinnis* adults. Larvae of *P. discolor* are readily distinguished from other *Psorophora* larvae by the presence of long, tracheated anal gills. Although known to feed both on livestock and on man, *P. discolor* probably is of minor economic importance in Indiana because of its relative infrequency in adult mosquito collections. Evidently there are no previously published records of the occurrence of *P. discolor* in Indiana.

Effect of Different Crop Plants on the Population Level of Pratylenchus penetrans in Muck Soil. JOHN M. FERRIS and MELVIN S. MILLER, Purdue University.—Population changes of *Pratylenchus penetrans* (Cobb, (1917) Filipjev & Schuurmans Stekhoven, 1941, an endo-phytoparasitic nematode, were followed in the field and in greenhouse pot cultures. Seven fields were sampled at monthly intervals between April and October 1962. Corn was grown in two of the fields, onions in another two, and potatoes in one field. The same three crop plants were grown in the greenhouse in clay pots filled with muck soil naturally infested with *P. penetrans* at two different levels of infestation. In the field plots and in the greenhouse test the smallest build-up of *P. penetrans* occurred where onions were grown.

Effects of Nutrition on Duration of Instars in Tropisternus (Coleoptera: Hydrophilidae. SHIDONKT O. HOSSEINIE, Indiana University.—In larvae of *Trophisternus lateralis nimbatus* (Say) fed heavily with mosquito larvae, the 1st instar lasts from 2 to 4 days, the 2nd from 3 to 5, the 3rd from 10 to 20, and the pupal stage from 10 to 15 days. In experiments beetle larvae were fed only *one* mosquito larvae per day (mosquito larvae graded according to size of beetle larvae but of standard size for each instar) for various periods: From hatching to molt 1; from molt 1 to adult; from hatching to molt 2; from molt 2 to adult; from molt 1 to molt 2; from hatching to molt 1 then after molt 2; from hatching to adult. Normal feeding of larvae was resumed after period of dieting. The effect on instar 1 and 2 is not great, and sometimes it is very low. Instar 3 was affected greatly, however, by dieting of instar 1 and 2. When instar 3 was also dieted the effect was even greater, and instead of 10-20 days it would take 1-3 months to be ready to pupate. No matter what instar was under diet the pupal stage was almost always close to the standard length. Evidently the

effect of the amount of food increases as the larva grows, and the larva must apparently reach a definite physiological condition before pupation.

Collembola and Mite Incidence in Wood Lot Soils Treated with Cyclodiene Insecticides. WILLIAM H. LEASE, Purdue University and JAMES W. BUTCHER, Michigan State University.—Replicated 4" x 4" soil cores were cut from wood lots treated with insecticides. Plots included soil treated with aldrin (2#/A) in 1960 plus dieldrin (3#/A in 1962, and soil treated with dieldrin only in 1962. Cores taken from adjacent wood lots having no history of cyclodiene treatment were studied for comparison. Comparisons of Collembola and mite abundance are given for the check and treated areas. In addition, the relative abundance of Collembola species is given for the three soil conditions. The relationship of apparent differences to GLC, cyclodiene, determinations is discussed.

The Threat of the Japanese Beetle to Indiana Crops. GEORGE E. GOULD, Purdue University.—The Japanese beetle has been found in most urban areas of Indiana, but occurs in farm lands around only a few cities. The only infestation starting in a rural area is that along the Illinois-Indiana state line. The infestation was reported in 1953 and in eight years had spread to over 300,000 acres, about half of which is in Newton and Benton Counties. High populations of the insect have been concentrated in about 1000 acres in Jefferson township (Newton County). Here during the 1962 season the beetles caused losses in yields up to 10 bushels per acre of soybeans and 8 to 12 bushels of corn. During the 1963 and 1964 seasons the population in this area showed a decided decrease, while farms five miles north in Washington township had an increase. Damage to these crops was associated with the crop maturity at the time of the peak of beetle abundance. This occurred around the first of August when the pods of soybeans were filling and the silks of corn were present. The beetle fed on the foliage of the beans and often destroyed the green corn silks. Losses from larval feeding on the roots of grasses and related plants were not noticeable. Although the infestation covers a large area, losses have been confined to fields in a small area. Farmers have had excellent control of beetles on soybeans by insecticide applications to the foliage. Control of the larvae and a general reduction of the beetle population on any one farm was obtained by a broadcast application of a soil insecticide commonly used against corn pests.

The Social Wasps in Indiana (Hymenoptera: Vespidae)

LELAND CHANDLER, Purdue University

The family Vespidae includes a relatively large number of species which may be identified as adults by the following set of morphological characters; pronotum reaching the tegulae; wings capable of being folded longitudinally; and length of the first discodal cell greatly exceeding that of the submedian cell. Seven subfamilies are recognized in North America (Bohart, 4), four of which occur in Indiana. Only the subfamilies Vespinae and Polistinae contain social species and it is with these groups that this paper is concerned.

Key to the Subfamilies of Vespidae
Occurring in Indiana

1. Middle tibiae each with one apical spur; tarsal claws with teeth or bifid; solitary species which typically use mud for nest construction and/or cell partitions 2
1.′ Middle tibiae each with two apical spurs; tarsal claws without teeth and not bifid; social (or rarely, parasitic) species which construct nests of "paper" 3
2. Mandibles short and broad; first abdominal segment petiolate; clypeus wider than long ..... Zethinae
2.′ Mandibles elongate, relatively slender, often crossing over one another; first abdominal segment petiolate (in which case clypeus is longer than wide) or truncate ..... Eumeninae
3. First abdominal segment truncate basally; hind wings without an anal lobe; nest of multiple brood combs enclosed in an envelope ..... Vespinae
3.′ First abdominal segment tapering basally; hind wings with an anal lobe; nest a single, exposed brood comb ..... Polistinae

The biology of the species of Vespidae is a panorama of diversity. Within the family are species that are solitary, semisocial, subsocial, social or socially parasitoid. Occasionally, certain species will fall into two of the above habit categories, depending upon environmental conditions. Excellent general accounts of vespid biology are those of Fichener and Michener (14), Richards (20), and Wheeler (23). Evans (9, 10) has presented two brilliant analyses of evolutionary behavioral patterns which include considerations of the vespids.

This paper is presented in the hope that the records of Indiana species and aids in their identification will provide a basis for studies by others. The social vespids are especially good subjects for behavioral, life history, social development or population ecology studies. Evans (9) has stated that *Polistes* is something of a "key genus" in understanding the origins of social life in wasps.

Literature citations have been minimized. The keys are modified from those published previously by Bequaert (1, 2) and Miller (16). Extensive bibliographies are to be found in most papers cited here.

Vespinae

Six species, belonging to the genus *Vespula*, are known to occur in Indiana. Of the six species, four are commonly called yellow-jackets and placed in the subgenus *Vespula;* the remaining two species are hornets and are placed in the subgenus *Dolichovespula.* The genus *Vespa*, containing one species, *V. crabro germana*, has been included for reasons given under that species.

The biology of the species of Vespinae has been treated by Duncan (7) in a most comprehensive fashion. Briefly, the nests of *Vespa* are usually constructed in hollow trees or other interspaces; those of *Vespula* (*s.s.*) are typically subterranean; whereas, those of *Dolichovespula* are aerial. The larvae are fed primarily on foodstuffs of animal origin, flies constituting a large proportion of the food. The adults are omnivorous, feeding on the nectar and pollen of flowers, the pulp and juices of ripe fruits and animal fluids from prey or carrion.

There is no intergradation in size of females so that queens and workers are distinct as castes. The species overwinter as fecundated queens which are found especially beneath logs. The queens, in hibernation, hold their wings beneath the body.

Because of their predaceous habits, the species are generally regarded as beneficial. However, the aggressiveness of the females in defense of the nest is well-known. Yellow-jackets pose the greatest problem because of their well-concealed, subterranean nests. In general, when nests of vespids occur in areas of human occupation, these nests and their populations should be destroyed because they constitute a definite hazard. The European hornet (*V. crabro germana*) does additional damage by stripping the bark from trees and shrubs to secure nesting materials.

Bequaert (1) and/or Miller (15, 16) have recorded all of the species from Indiana with the exception of *V. arenaria.*

Key for the Identification of Species of Vespinae Occurring in Indiana

1. Head very large, swollen behind the eyes; vertex long; posterior ocelli on a line connecting the upper lobes of the eyes and 4 to 6 times as far from the occiput as from each other ..... *Vespa crabro germana*

1.′ Head not unusually large, not swollen behind the eyes; vertex short; posterior ocelli on a line connecting the tops of the eyes and subequally distant from the occiput as from each other ..... (*Vespula, s.l.*) 2

2. Space between eye and base of mandible (oculomalar space) very short in queens and workers, less than half the length of the penultimate antennal segment in the male. (Yellow-jackets, subgenus *Vespula*) 3

2.′ Space between eye and base of mandible as long as, or longer than, the penultimate antennal segment in the queen, worker and male. (Hornets, subgenus *Dolichovespula*) 6

3. Mesonotum with 2 complete, longitudinal, yellow lines or stripes ..... *Vespula* (*V.*) *squamosa*

3.′ Mesonotum without longitudinal lines (occasionally some individuals will have 2 short lines or dash-like marks but these never extend full length of the mesonotum) 4

4. First abdominal segment narrowed basally, the tergite somewhat depressed immediately behind the anterior margin; occipital carina obsolete ventrally, not reaching the bases of the mandibles; erect hairs on first metasomal tergite black .....*Vespula* (*V.*) *vidua*

4′. First abdominal segment not narrowed basally, the tergite not depressed; occipital carina complete, reaching mandibular bases; erect hairs on first metasomal tergite gray 5

5. Females: Yellow hind margin of pronotum gradually widened; yellow band of first abdominal tergite extensive, enclosing a transverse, median, black area; black clypeal marks usually in the form of separated spots arranged as a triangle, or these may be absent. Males: Seventh abdominal tergite abruptly depressed at its basal third, forming a distinct angle or notch with the distal portion; apical edge of last tergite without a median notch .....*Vespula* (*V.*) *maculifrons*

5′. Females: Yellow hind margin of pronotum parallel-sided; yellow band of first abdominal tergite restricted as apical border, notched medially and without any tendency to enclosed the black area; black clypeal marks usually united into an anchor-shaped spot. Males: Seventh abdominal tergite evenly convex, not abruptly depressed; apical edge of last tergite with a distinct median notch .....*Vespula* (*V.*) *vulgaris*

6. Pale markings yellow .....*Vespula* (*D.*) *arenaria*

6′. Pale markings white or ivory .....*Vespula* (*D.*) *maculata*

Vespa crabro germana Christ

This is the introduced European hornet. The species is extending its range in North America and has reached the Mississippi River in Tennessee (Mullet, 17). It is included here not only because the possibility exists that it may eventually become established in the state, but also for the following reasons: 1) the species has been reported from the Chicago area by Bromley (6) but this report has been generally disregarded; 2) In July, 1951, two large wasps, fitting the description of this species, were observed stripping bark from lilac in a yard near Friendship (Ripley County); and, 3) In February, 1962, the aerial nest of a hornet with a specimen of *V. crabro germana* mounted at the entrance was seen in a local home. The nest was collected along the Wabash River near Granville Bridge (Tippecanoe County). The association of the specimen with the nest, which appeared to be that of *Vespula maculata*, could not be satisfactorily confirmed.

Vespula (*V.*) *squamosa* (Drury)

V. squamosa is the second most common yellow-jacket in Indiana, occurring throughout the state. Both sexes are readily recognized by the longitudinal yellow lines on the mesonotum. The species differs in several ways from other species in the Vespinae. In coloration and in

color pattern, the workers and males are alike. The queens differ by being more orange than yellow, and in being marked more extensively by that color. The range of *V. squamosa* extends southward into Guatemala (Miller, 16), exceeding by far the southern range limits of other species.

Taylor (22) reported a queen of *V. squamosa* from a nest of *V. vidua*. This observation, and others cited by Michener and Michener (14), indicate that *V. squamosa* may occasionally be a social parasitoid.

Vespula (*V.*) *vidua* (Saussure)

Since *V. squamosa* was "run out in the key" on the basis of distinctive color pattern, the relationship of *V. squamosa and V. vidua* was not obvious. The species are related, however, as both have the basal tergite narrowed and depressed basally and the occipital carina becomes obsolete ventrally in both species. The inferred parasitoid-host relationship is, therefore, in keeping with the theory that social parasitoids are derivatives of related nest-building species.

Both Bequaert (1) and Miller (16) reported *V. vidua* from Indiana (without locality), but the Indiana distribution indicated by Bohart and Bechtel (5) is too extensive (throughout the state). We have taken V. *vidua* in Fulton, LaPorte, Starke and Tippecanoe counties. It probably occurs throughout the northern third of the state. In the Christmas tree plantings in the sandy areas of LaPorte County, it is the most commonly collected species.

Vespula (V.) maculifrons (Buysson)

This species is the most common yellow-jacket in Indiana and is found throughout the state. *V. maculifrons* is related to *V. vulgaris*, and the two have overlapping ranges in northern Indiana. The two species are rather easily separated by color patterns in the females; by the characters of the last abdominal tergite in the males. Miller (16) has recorded intergradations of color pattern in the area of sympatry and has interpreted this as indicating hybridization.

Vespula (*V.*) *vulgaris* (L.)

This is a Holarctic species and is the rarest of Indiana yellowjackets. Miller (16) recorded it from the Shades State Park (Montgomery County) where it must certainly be a boreal relict. Our only record is based upon a single male from Fort Wayne (Allen County).

Vespula (*D.*) *arenaria* (Fab.)

On the basis of coloration, this species would be called a yellowjacket. Morphologically (long malar space) and biologically (aerial nests), the species is a hornet. It is apparently rare in Indiana. Our records are based upon two workers taken from *Melilotus alba*, north of Medaryville (Pulaski County) by Earle Cross and myself.

The record by Blatchley (3) for Vigo County is undoubtedly erroneous. Bequaert (1) tentatively assigned the record to V. (*V.*) *rufa* var. *consobrina* (Sauss.). On the basis of existing data, the specimens were probably *V. maculifrons*.

Vespula (D.) maculata (L.)

This is the common and widespread bald-faced hornet. It occurs throughout the state. The aerial nests are familiar sights to most persons and they are commonly displayed. The distinctive color and stable color pattern readily identifies the species.

Polistinae

The so-called single-comb wasps are represented in Indiana by five species, one of these with two recognized subspecies. The species belong in the genus *Polistes*.

The biology of polistine wasps is less well-known than that of the vespines and appears to be more variable. The species overwinter as fecundated females (there is a question as to whether these are queens or workers or both). Overwintering quarters are more diverse in this genus with crevises in rocks and in walls of buildings being likely sites. The colonies are very much smaller than those of *Vespula* and, while the females are aggressive in defense of the nest, they are less so than species of *Vespula*.

The value of *Polistes* spp. as predators is probably of greater importance than has been recognized. The works of Lawson (12, 13), Rabb (18) and Whitcomb and Bell (24) are significant here. The larval food is predominantly the larvae of Lepidoptera which are malaxed into pellets. Since many of these larvae are those of pest species, polistine wasps exert a significant pressure on the pest populations.

Bequaert (2) has recorded the following species from Indiana: *P. annularis, P. f. fuscatus, P. f. pallipes, P. F. variatus, P. metricus, P. rubiginosus,* The record of *P. exclamans* appears to be new.

Key to the Species of *Polistes*
Occurring in Indiana

1. Females: (as viewed from the side) First abdominal tergite slightly convex, gradually sloping toward the base; second abdominal sternite convex but not bulging; (as viewed from above) first abdominal segment somewhat longer than its apical width. Males: Apical sternite without a median tubercle 2

1'. Females: (as viewed from the side) First abdominal tergite strongly convex and sloping abruptly toward the base; second abdominal sternite strongly convex, bulging; (as viewed from above) length of first abdominal segment less than, or equal to, its apical width. Males: Apical sternite with a median tubercle 3

2. First abdominal tergite mahogany or black, but always with a yellow apical margin, remainder of abdomen black; thorax uniformly mahogany or dark brown. Wings extremely dark. Large individuals ..... *P. annualaris*

2'. Thorax and abdomen extensively yellow, usually with light brown ground color; most tergites with yellow apical bands. Wings light. Small individuals ..... *P. exclamans*

3. Head, thorax and abdomen almost wholly unicolorous, ferruginous. Wings purplish-black, Large individuals. ..... *P. rubiginosus*

3′. Head, thorax and abdomen not unicolorous, or if appearing so, dark in color, not ferruginous. Wings light or dark, but not purplish. Medium to small individuals 4

4. Head, mesonotum and lateral blotches on first and second tergites mahogany (mesonotum, if at all black, always with longitudinal mahogany lines); pleura usually mahogany but occasionally with black confined to sutures and their margins; yellow, if present, confined to apical margin of first tergite and rarely to reduced propodeal lines; remainder of abdomen black or dark mahogany. Colors of head and thorax usually contrasting with darker colored abdomen. Wings very dark ..... *P. metricus*

4′. Color combination not as above. **Either extensively** marked with yellow, including two lines on the propodeum; or mesonotum black; pleura entirely black or nearly so; colors of head and thorax not contrasting with abdomen. Wings lighter in color than above 5

5. Mesonotum and pleura largely black; yellow, if present, restricted to apical margin of first tergite and occasionally reduced propodeal lines. Legs dark except tarsi which are white ..... *P. fuscatus pallipes*

5′. Thorax marked with yellow, including two propodeal lines; several tergites usually with yellow apical margins and lateral blotches on first and second tergites with yellow. Legs dark, gradually becoming lighter in color toward the tarsi which, though white or yellowish, do not contrast conspicuously ..... *P. fuscatus fuscatus*

Polistes annularis (L.)

This large polistine wasp is undoubtedly more common in Indiana than our records indicate. *P. annularis* is easily identified by its dark mahogany and black body and the yellow apical band on the first tergite. *P. annularis* and *P. exclamans* are representative of two related groups as indicated by their placement in the key. Additionally, the apical antennal segments are reddened in both, a condition not found among other species.

P. annularis has been collected in Clark, LaPorte, Montgomery, Perry and Tippecanoe counties. It has also been observed in large numbers at Turkey Run State Park (Parke County). In all instances, except the unknown LaPorte site, the species has been collected in areas having steep, rocky bluffs.

Polistes exclamans Viereck

P. exclamans is the smallest of the Indiana polistine wasps and also the least common. It has been collected thus far only in Posey and Perry counties. It probably occurs in those counties along the Ohio River westward from Harrison County and may occur northward along the Wabash River.

Polistes rubiginosus Lep.

This species has been collected in Clark, Dearborn, Harrison, Knox, Lawrence, Monroe, Posey, Ripley, Spencer and Vanderburgh counties.

Its range is limited to the southern part of the state where it is relatively common. The large size, ferruginous or reddish unicolorous body, and dark wings with purplish reflections, mark it as a striking wasp. Occasional specimens will show a suffusion of black on the thorax.

Polistes metricus Say

P. metricus was described by Say (21) from specimens collected in Indiana, where it was reported to occur abundantly, and in Louisiana. This is one of our most common species; however, it is misidentified so often as *P. fuscatus pallipes* that much of the information concerning it is confused.

At the one extreme of coloration, the head, thorax and first two abdominal segments are mahogany, the remainder of the abdomen being black. Individuals so-colored are similar in appearance to *P. annularis* (Say, 21; Bequaert, 2). At the other extreme, the mesonotum is black, but always with mahogany lines; the pleurae have black along the sutures; and the first abdominal tergite has a yellow apical band. This color form is often mistaken for *P. fuscatus pallipes*.

The wings of *P. metricus* are much darker than those of *P. fuscatus pallipes* and, when observed in series, the difference is readily apparent. Likewise, while the tarsi of both species are light in color, those of *P. fuscatus pallipes* contrast markedly with the darker tibiae.

The distribution of *P. metricus* extends over much of the state. We have no records north of a line drawn from Tippecanoe to Allen counties. Moving southward from this line, *P. metricus* becomes increasingly abundant.

Polistes fuscatus (Feb.)

P. fuscatus is a polytypic species with eight recognized subspecies (Bohart, 4; Krombein, 11). The criteria for subspecific recognition are geographic distribution of color forms. Of the currently accepted subspecies, three have been recorded from Indiana (Bequaert, 2). These are *P. f. fuscatus* (Fab.) (from Bloomington), *P. f. pallipes* Lep. (from Winona Lake), and *P. f. variatus* Cresson (Indiana, without locality). In this paper, only two of the subspecies, *P. f. fuscatus* and *P. f. pallipes*, are recognized as occurring in the state. Previous state records for *P. f. variatus* are assigned to *P. f. fuscatus*. *P. f. variatus* is a valid subspecies but is of more western distribution (4).

Both subspecies occur abundantly throughout the state. They are found together in typical color patterns as well as intergradations. Rau (18) recorded *P. pallipes* and *P. variatus* from the same nest. The number of individuals assignable to *P. f. fuscatus* increases from north to south; conversely, the number referrable to *P. f. pallipes* increases from south to north. Such a distributional color pattern was plotted by Enteman (8).

Literature Cited

1. Bequaert, J. 1932. A tentative synopsis of the hornets and yellow-jackets of America. Entomol. Americana (n. s.) **12**:71-138.

2. ————————. 1940. An introductory study of **Polistes** in the United States and Canada with descriptions of some new North and South American forms. Jour. New York Entomol. Soc. **48**:1-31.

3. Blatchley, W. S. 1896. Notes on the winter insect fauna of Vigo County, Indiana—VIII. Psyche **7(248)**:455-458.

4. Bohart, R. M. 1951. Family Vespidae, in C. F. W. Muesebeck, et al., Hymenoptera of America north of Mexico. Synoptic catalog. U. S. Dept. Agric. Monograph 2, pp. 875-907.

5. ———————— and R. C. Bechtel. 1957. The social wasps in California (Vespinae, Polistinae, Polybiinae). Bull. California Insect Survey **4(3)**:73-102.

6. Bromley, S. W. 1931 Hornet habits. Jour. New York Entomol. Soc. **39**:123-129.

7. Duncan, C. D. 1939. A contribution to the biology of North American vespine wasps. Stanford Univ. Publ. Biol. Sci. **8**:1-272.

8. Enteman, Wilhelmine M. 1904. Coloration in **Polistes**. Carnegie Institution of Washington Publ. 19:1-88.

9. Evans, H. E. 1958. The evolution of social life in wasps. Proc. Tenth Intern. Congress Entomol. (1956) **2**:449-457.

10. ————————. The evolution of prey-carrying mechanisms in wasps. Evolution **16(4)**: 468-483.

11. Krombein, K. V. 1958. Hymenoptera of America north of Mexico. Synoptic Catalog U. S. Dept. Agric. Monograph 2, First Supplement: 162.

12. Lawson, F. R. 1959. The natural enemies of hornworms on tobacco. Ann. Entomol. Soc. America **52(6)**:741-755.

13. ————————. R. L. Rabb, F. E. Guthrie, and T. G. Bowery. 1961. Studies of an integrated control system for hornworms on tobacco. Jour. Econ. Entomol. **54(1)**:93-97.

14. Michener, Charles D. and Mary H. Michener. 1951. American Social Insects. A book about bees, ants, wasps, and termites. L. Van Nostrand Co., Inc., New York, xv + 267 pp., 109 figs.

15. Miller, C. D. F. 1958. Distributional and nomenclatorial problems in some forms of **Vespula** in North Amrica (Hymenoptera: Vespidae). Proc. Tenth Intern. Congress Entolmol. (1956) **2**:257-264.

16. ————————. 1961. Taxonomy and distribution of Nearctic **Vespula**. Canad. Entomol. **93**, Supplement 22:1-52.

17. Mullet, R. 1956-58. (Reports of **Vespa crabro germana** in Tennessee). U. S. Dept. Agric. Coop. Econ. Insect Rpt. **6(41)**:983; **8(45)**:932.

18. Rabb, R. L. 1960. Biological studies of **Polistes** in North Carolina. Ann. Entomol. Soc. America **53(1)**:111-121.

19. Rau, P. 1939. Population studies in colonies of **Polistes** wasps; with remarks on the castes. Ecology **20(3)**:439-442.

20. Richards, O. W. The Social Insects. Philosophical Library, Inc., New York xiv + 15 — 219.

21. Say, Thomas. 1837. Description of new North American Hymenoptera and observations on some already described. Boston. Jour. Nat. Hist. **1(4)**:361-416

22. Taylor, Leland. 1939. Observations on social parasitism in the genus **Vespula** Thomson. Ann. Entomol. Soc. America **32**:302-315.

23. Wheeler, W. M. 1928. The Social Insects: Their Origin and Evolution. Harcourt, Brace and Co., New York. xviii + 378 pp.

24. Whitcomb, W. H. and K. Bell. 1964. Predaceous insects, spiders and mites of Arkansas cotton fields. Arkansas Agric. Exp. Sta. Bull. 690:1-84.

Protura of Wayne County, Indiana

WALTER BRIGADIER[1], and GERTRUDE L. WARD, Earlham College

The most recent account of Indiana Protura was published in 1957 by Leland Chandler (2) who collected various nymphal and adult stages in 1954 from a woods near West Lafayette. The present study concerns forms collected in Wayne County during October, 1963, near Richmond. It is an attempt to correlate soil types and vegetation with the insects' habitat.

The authors are grateful for the support given by the National Science Foundation.

Proturans were found six miles south of Richmond off of U. S. 27 in Sedgwick's Woods and in the Hayes Arboretum near U. S. 40 at the eastern city limits. On October 2 a total of 36 specimens were obtained from Sedgwick's Woods, and on October 26 an additional 104 specimens were collected. Also on October 26 soil samples from the Hayes Arboretum yielded nine proturans. All the specimens, a total of 149, have been placed tentatively in the family Eosentomidae. A series has been sent to S. L. Tuxen at Copenhagen, and the remainder are on deposit in the Joseph Moore Museum at Earlham College. Table 1 shows the nymphal and adult stages collected from each locality.

TABLE 1.

Nymphal and adult stages of Protura collected at two sites in Wayne County, Indiana, in 1963.

Form	Locality and Date		
	Sedgwick's Woods		Hayes Arboretum,
	Oct. 2	Oct. 26	Oct. 26
Protonymph	6	21	3
Deuteronymph	10	25	1
Tritonymph	13	29	3
Adults: Male	5	18	0
Female	2	11	2
Total: 149	36	104	9

Collection Method

A simple Berlese funnel was used for all soil samples and the insects dropped into 70% ethanol. The delicate body wall is subject to rupture.

Soils

The soil in Sedgwick's Woods from which the insects were obtained consists entirely of Miami silt loam. Bushnell *et al.* (1) describes this soil as consisting of ". . . light brown friable silt loam over light yellowish-brown friable silt loam which grades rather abruptly, at a depth of 10 inches, into yellowish-brown silty clay loam. The upper layers tend to have a fine granular structure. The subsurface layer lacks definite arrangement. Surface drainage is naturally good." The soil was basic with a pH of approximately 7.4.

[1]Present address: Peace Corps, Nairobi, Kenya.

The soil samples from Hayes Arboretum consist primarily of Miami silt loam and some Fox silt loam with a gradual mutual intergrade. Bushnell *et al.* (1) say, "The cultivated surface soil of Fox silt loam, to a depth of about 8 inches, consists of brown friable silt loam, which grades slightly into brown silt loam underlain, at a depth of 12 or 15 inches, by reddish-brown silty clay loam." This soil is well drained into surrounding soils. Here too the pH was approximately 7.4.

Proturans were never found below the first two inches of soil and the best yield in numbers was from the decaying lower leaves and the first one-half inch of soil.

Plants

Ewing (3) says, ". . . In woods where the trees form a complete canopy overhead proturans are seldom found." However, all our specimens were found in wooded areas where an almost complete canopy was present. In Hayes Arboretum the trees are mostly beech *(Fagus grandifolia)* with a few widely scattered maples. In this particular section there is no secondary layer of trees or shrubs, and the ground plants are sparse. In October a few *Botrychium*, *Smilax*, *Lappula* and *Bidens* are present. Sedgwick's Woods is predominantly beech-maple. A few scattered *Juglans nigra*, *Quercus alba* and *Juniperus virginiana* are *present*. Much layering is evident, but the canopy is not as complete as in the Hayes Arboretum. Many more ground plants are present, including *Trillium* spp., *Eupatorium rugosum*, and *Vitis* spp. In both areas there were approximately two inches of decaying leaves and newly fallen leaves. It has been suggested that proturans live on partially decayed leaves. Where areas were leafless there were never proturans present in the soil. This may be as much a matter of moisture as of feeding.

Moisture

When the first samples were collected, the area had been virtually without rain for 44 consecutive days, and when the second specimens were found, for 68 days. The total rainfall for September and October was 0.28 of an inch in contrast to 1962's 4.14 inches. Only in 2 percent of the samples were proturans obtained directly from the leafy organic matter. The remaining samples were from beneath decaying logs where more moisture was retained. Under logs there was very little non-decayed leafy matter, but various fungi were present. It is possible that these plants serve as food.

Conclusion

We suggest that the proturans of Wayne County prefer a basic, well drained soil found in a woodland. Three other soil areas were extensively sampled. Two of these were slightly acid, and the other was neutral. The vegetation differed considerably from the two areas described above. No proturans were obtained.

Literature Cited

1. Bushnell, T. M. et al. 1925. Soil survey of Wayne County, Indiana. U. S. Department of Agriculture.
2. Chandler, Leland. 1957. The orders Protura and Diplura in Indiana. Proc. Ind. Acad. of Sci. 66:112-114.
3. Ewing, H. E. 1940. The Protura of North America. Ann. Ent. Soc. Amer. 33(3): 495-551.

Insects and Other Arthropods of Economic Importance in Indiana in 1964

J. V. Osmun and R. A. Bram, Purdue University[1]

Weather conditions, especially the continuing period of drought, noticeably influenced the abundance and importance of certain species of insects in Indiana in 1964. The Fall of 1963 was quite dry having a deficit of between 3.7 and 5.9 inches of rainfall. This condition was punctuated by below normal precipitation during the following winter. The heavy rains of March and April did not compensate, and the summer and fall conditions aggravated the situation by being extremely dry in most localities.

In the Evansville area, rainfall from April through September was 3.6 inches below normal while the deficit in central Indiana was 4.90 inches. By considering the additive effect of last year and this year, it can be seen that unusually dry conditions prevailed. The temperatures during 1964 have not been markedly out of line with the long term averages. Dryness, then, is the principal factor.

Field and Crop Insects

Alfalfa weevil (*Hypera postica* (Gyll.)). Perhaps the most destructive of all alfalfa pests, the alfalfa weevil has been systematically extending its range throughout the Mid-West for the past several years. It was first reported from Hart County, Kentucky in July, 1959 (Cooperative Economic Insection Report 9(45): 980) and from Belmont County, Ohio in September, 1960 (CEIR 11(9): 111). The locations of these original discoveries and the subsequent spread of the pest within these states would seem to suggest that the alfalfa weevil was introduced into Kentucky from its southern neighbor, Tennessee and into Ohio from West Virginia. Thus, for at least the past four years populations of *H. postica* have been converging on Indiana from both south and east.

Therefore, it was not too surprising that larvae of *H. postica* were discovered for the first time in Indiana in Knox County on May 13, 1964. Extensive surveys of alfalfa in all other counties in the southern quarter of the state revealed that the following additional counties were also infested: Harrison, Vanderburgh, Gibson, Spencer, Perry, Warrick, Dubois, Jefferson, and Switzerland. Each of the ten counties are located in the southern quarter of the state within 60 miles of the Ohio River. In each instance that the alfalfa weevil was collected there was no evidence of economic damage and generally only one or two specimens were obtained from each field. In no case did numbers exceed one adult or larval specimen per 500 sweeps with a 15 inch net. Experience in other states in which the alfalfa weevil has been newly introduced (for example, Ohio, Maryland, West Virginia, etc.)

[1]Information for this summary has been provided by: J. A. Clark, M. L. Cleveland, H. O. Deay, R. C. Dobson, R. E. Dolphin, R. T. Everly, J. J. Favinger, R. L. Giese, G. E. Gould, G. E. Lehker, D. L. Matthew, J. D. Paschke, D. L. Schuder, M. C. Wilson.

suggests that economic damage may be expected approximately two years after trace numbers are first discovered. Using this experience as a guide, it is anticipated that moderate to severe damage to first growth alfalfa will occur in 1966 in those counties adjacent to the Ohio River and, possibly, throughout the southern quarter of the state.

Figure 1 illustrates he present status of the alfalfa weevil in Indiana and adjacent states.[2] Examination of this figure reveals that the alfalfa weevil entered Indiana from Kentucky and may be expected to continue the northward extension of its range unimpeded. There is also a distinct possibility that within two years another population of *H. postica* will enter the north-east section of Indiana from Ohio.

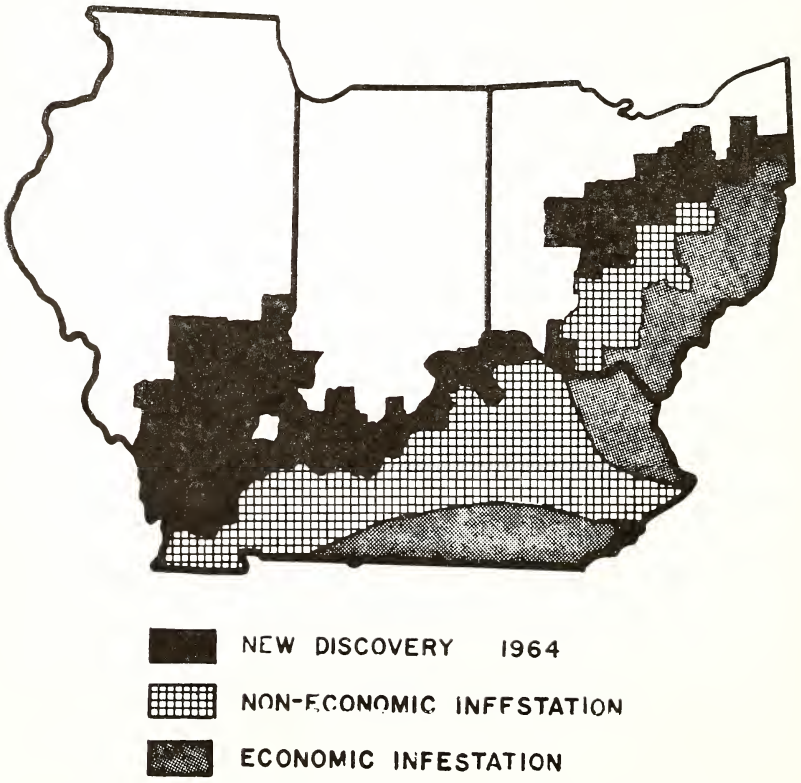


Figure 1. Alfalfa weevil distribution in Kentucky, Illinois, Indiana and Ohio.

Armyworm (Pseudaletia unipuncta (Haworth)). Although the wet, cool spring would seem to have favored extensive populations of armyworms, large population patterns did not materialize. Scattered infestations were evident with only minor local areas showing damage.

[2]Distributional data for Kentucky was generously supplied in a personal communication by B. C. Pass; for Ohio by R. E. Treece; and for Illinois by H. B. Petty and C. E. White.

A billbug *(Sphenophorus* sp.) caused serious economic damage to a few scattered cornfields in the central and southwestern sections.

Blister beetles *(Epicauta* spp.) were again of no economic importance in 1964.

The cabbage looper *(Trichoplusia ni* (Hubner)) was abundant in commercial cabbage fields and home gardens throughout the state.

The cereal leaf beetle *(Oulema melanopa* (L.)) continued to extend its range in Indiana. The following counties were found to be infested for the first time in 1964; Wells, Jay, Newton, Tipton, Madison, Boone, and Randolph. However, high populations were confined to oats in La-Porte and St. Joseph counties. In this area peak oviposition on oats occurred around May 28, 1964 with egg counts as high as 300 to 350 eggs per 100 stems. Eighty percent hatch was achieved by June 5th with maximum populations reaching approximately 100 to 150 larvae per square foot. Pupation was considered 70 percent completed by June 12th and first emergence of summer adults probably occurred around June 10th. Emerging summer adults reached peak numbers on July 1 and 2 with a subsequent rapid drop in numbers. By July 24th the summer adults were nearly 100 percent in aestivation.

In an effort to introduce biological control agents, a total of 154 adult eulophid parasites, *Aprostocetus julis* (Walker) [=*Tetrastichus julis* (Walker)], were released in severely infested oats fields in St. Joseph County during May and early June 1964. These gregarious larval parasites originated in Italy and were collected by USDA entomologists and J. D. Paschke of Purdue during April and early May. Evaluation of whether or not this speces is established in Indiana will be undertaken in the spring of 1965. If established, it is hoped that the parasite will have adequate impact on the population to bring about suppression of economically significant densities of the cereal leaf beetle. Further releases are planned in 1965. In addition, three other species, two solitary larval parasites and an egg parasite, will be available for liberation and colonization in 1965. One of these, *Thersilocus* sp. (probably *moderator* (L.)), has shown promise in laboratory tests. It is a single generation species with obligatory diapause and exerts very significant biotic pressure on *O. melanopa* populations in Italy.

Chinch bug *(Blissus leucopterus* (Say)). The first economic infestation of chinch bugs reported in three years occurred in the northwest section. Nymphal populations completely inhibited development of millet seedlings planted immediately following wheat harvest. Slight damage was also apparent in border rows of adjacent corn. Of 4,000 acres of millet planted, approximately 3,000 acres were lost.

Common stalk borer *(Papaipema nebris* (Guenee)) populations were of no economic importance in 1964; however reports of activity were received from many localities.

Corn earworm *(Heliothis zea* (Boddie)) After the extremely low infestations of corn earworm in 1963, populations approached normal levels in 1964. The fall insect survey revealed that, on a state-wide basis, 9.4 percent of corn plants were infested in 1964 compared to 2.0 percent in 1963 and 17.6 percent in 1962. Highest infestations occurred in the

southern half of the state, particularly in the south, west and south-southwest areas where percent of corn plants infested was 17.6 percent and 14.8 percent respectively. Despite the general increase in population levels, infestations remaind light on tomatoes in the commercial growing areas.

Corn leaf aphid *(Rhopalosiphum maidis* (Fitch)) populations reached maximum development by mid-July in the southern quarter of the state and systematically developed northward. Infestations this year exceeded the previous year and this high population density combined with summer drought conditions resulted in considerable loss in yield. On a state-wide basis, 7.9 percent of corn plants demonstrated severe infestations (compared with 3.8 percent in 1963), 20.6 percent had moderate infestations (14.8 percent in 1963), and 37 percent exhibited light infestations (34.6 percent in 1963). Maximum infestation was found to be in the northern half of the state where over 67 percent of plants in each area were infested.

Cutworms were of no general economic concern in 1964. Localized infestations of the black cutworm *(Agrotis ipsilon* (Hufnagel)) caused moderate economic damage to corn seedlings in the northern half of the state and several scattered western areas. The variegated cutworm *(Peridroma saucia* (Hubner)) averaged 10 to 15 larvae per square foot in commercial potato plantings in Jasper County.

European corn borer *(Ostrinia nubilalis* (Hbn.)) populations were considerably higher in 1964 than in the two previous years. In 1964 the state averaged 59.6 borers per 100 plants as compared with 35.7 in 1963 and 28.9 in 1962. As in previous years, the north-northwest and north-northcentral areas demonstrated the highest percentage of infested plants and the greatest number of borers per 100 plants (93.6 in the north-northwest areas and 102.0 in the north-northcentral area). However the south-southwest and south-southcentral areas also experienced exceptionally high infestations with 95.7 and 119.2 borers per 100 plants respectively. In the south-west and south-central areas populations were lower than in either 1962 or 1963. In all other areas of the state, population estimates were higher than in the previous two years. Loss in yield in 1964 approximated 1.5 percent as compared to 1.1 percent in 1963.

Fall armyworm *(Laphygma frugiperda* (J. E. Smith)) populations remained at insignificant levels throughout the state for the third consecutive year.

The fruit or vinegar fly (*Drosophila melanogaster* (Meig.)) continued to decline for the second consecutive year and was of minor significance in tomato growing areas. Dry conditions were influential in the decline.

Hessian fly *(Phytophaga destructor* (Say)) Race B field populations of Hessian fly capable of infesting the W38 resistant wheats (Dual, Monon, Reed, and Redcoat) continue to be a threat, although the average infestations were lower this year than in 1963. Only 35 percent of the 361 certified wheat fields sampled, demonstrated an infestation with Hessian fly. This year, for the first time, three out of

80 Knox 62 fields sampled showed slight infestations indicating the presence of Races C or D. These fields were located in Porter, Tippecanoe, and Warrick counties.

Tomato and Tobacco hornworms (*Proptoparce quinquemaculata* (Haworth) and *P. sexta* (Johan.)) were more numerous in 1964 than in previous years. Preliminary evaluation of light trap collections suggest that populations in the southern half of the state were considerably higher than those in the northern half. However, economic damage remained at a low level throughout the state.

English grain aphid *(Macrosiphum avenae* (Kirby)) This insect remained at the non-economic level on small grains throughout the state. Maximum densities reached an average of 5 aphids per sweep in the central section of the state during mid-June and thereafter population densities rapidly decreased.

Grasshoppers (all species) An adult grasshopper survey, conducted during late August and early September, revealed that the grasshopper populations reached maximum densities in alfalfa field margins of 5 to 7 adults per square yard; even these figures suggest non-economic populations. Elsewhere in the state population desities were less than 1 adult per square yard. *Melanoplus femurrubrum* (DeG.) tended to dominate the grasshopper population throughout the state. Other grasshopper species commonly observed included *Melanoplus differentialis* (Thos.) (especially in fence rows and ditches), *Melanoplus bivittatus* (Say), *Dissosteira carolina* (L.), and an occasional *Schistocerca* spp.

Japanese beetle (*Popillia japonica* Newman) adult populations began appearing as scattered, light infestations by mid-June. Although many of these infestations were of local concern to home owners, agricultural damage was restricted to a limited infestation in Newton county. On six selected farms in this area adults averaged 58 per 100 feet of row on soybeans and damage to corn silk by adults averaged 70 percent of the plants. Peak adult activity was apparently reached by the end of July.

Meadow spittlebug *(Philaenus spumarius* (L.)) nymphal populations reached economic levels primarily in the central section of the state where nymphal masses on alfalfa averaged 15 per 10 stems. Nymphal populations also approached economic levels in the southwest section, reaching an average density of 8 spittle masses per 10 stems. Adult populations were non-significant, and exhibited maximum numbers by mid-June in the central and east-central sections. By early September highest adult populations were observed in the north-east section of the state.

Northern corn rootworm (*Diabrotica longicornis* (Say)) adults caused severe silk damage and prevented "ear-filling" in many late-planted fields. Populations are increasing in fields of continuous corn in Henry, Franklin, Wells, and Montgomery counties. In Montgomery County the loss due to larval feeding was 30 bushels per acres where adjacent treated rows produced 94 bushels per acre.

Pea aphid (*Acyrthrosiphon pisum* (Harris)) populations were generally non-economic throughout the state. Populations reached maxi-

mum densities in mid-July and rapidly decreased thereafter. Maximum populations in alfalfa (averaging 60 or more adults and nymphs per sweep) were observed in the north-east and north-central sections and the central third of the state. Populations in the southern third of the state were comparatively insignificant.

Potato leafhopper (*Empoasca fabae* Harris) populations again reached economic levels in many areas of the state. This species was most abundant in the north-west section of the state, reaching maximum populations of 12 adults per sweep by the middle of June and then gradually declining in numbers. Populations in the central third remained stable through July (averaging around 3 adults per sweep), declining somewhat in August. Lowest populations were observed in the southern third of the state, particularly the south-east section. Most significant injury to alfalfa developed during late August to mid-September, reflecting the drouth conditions experienced throughout the state.

Six spotted leaf hopper (*Macrosteles fascifrons* (Stal.)) adults were unusually abundant on oats in LaPorte and St. Joseph counties.

Southern corn rootworm (*Diabrotica undecimpunctata howardi* Barber) populations were generally non-economic throughout the state. However, in several scattered areas silk feeding resulted in reduced yields of seed corn.

A soybean cyst nematode (*Heterodera glycines* Ichinohe) aerial survey was conducted by the Division of Entomology, Department of Conservation over 276 square miles of southwestern Indiana. Results of this survey were negative.

Wheat stem maggot (*Meromyza americana* Fitch) Few reports were received and it was much less important than in 1963.

White grubs (*Phyllophaga* spp. and *Cyclocephala* spp.) Populations were generally inconsequential throughout the state. However, an isolated population of *Phyllophaga* sp. caused economic damage to several acres of mint in the north-west section of the state, and *Cyclocephala* sp. was observed to be abundant in sod in Tippecanoe County.

Wireworms (*Melanotus* spp.) of localized destructive numbers were present in several northwestern counties. Heaviest damage was in Porter County.

Fruit Insects

European red mite (*Panonychus ulmi* (Koch)) The first hatch for overwintering eggs was noted in the Vincennes area on April 16. Populations began an immediate buildup and continued to be quite persistent through, in many cases, September. The European red mite was considered to be our No. 1 arthropod pest of apples.

Four-spotted spider mite (*Tetranychus canadensis* (McGregor)) Only a few isolated captures of this mite were noted during the current year.

The two-spotted spider mite (*Tetranychus telarius* (L.)) became active in early April and continued to be a pest through September. The populations of two-spotted spider mite were not as troublesome as those of European red mite.

Apple maggot (*Rhagoletis pomonella* (Walsh)) was not a problem in Southwestern Indiana. However, it was troublesome in a number of northern Indiana orchards.

While codling moth (*Carpocapsa pomonella* (L.)) is perhaps potentially the most destructive of our apple insects, this potential was not realized during the 1964 growing season. Instances of heavy commercial damage by this insect in the Vincennes area have not been brought to our attention. However, one orchard, abandoned with regard to insecticidal control after the first cover spray was applied, did develop a population reaching approximately 90 percent infestation before the season was completed. Codling moth adult activity continued through October.

Forbes scale (*Aspidiotus forbesi* Johnson) was not a general problem. Only a few isolated populations are known.

Lesser peach tree borer (*Synanthedon pictipes* (Grote & Robinson)) Damage by this insect was quite prevalent and heavier than in past years. This insect is rapidly becoming one of our No. 1 peach problems. Adult emergence began in April and adults continued to emerge into October of 1964.

Oriental fruit moth (*Grapholitha molesta* (Busck)) First adults of the season were taken on April 2. Populations continued to be active in peach orchards for the balance of the season. There were several instances of oriental fruit moth injury to apple. Oriental fruit moth activity continued through October.

Peach tree borer (*Sanninoidea exitiosa* (Say)) was not as troublesome this year as in past years. In fact, infestations were difficult to find.

The plum curculio (*Conotrachelus nenuphar* (Herbst)) was not as damaging as in the past two years. However, there were several instances of commercial injury by this insect.

Red-banded leaf roller (*Argyrotaenia velutinana* (Walker)) populations were extremely scattered and instances of damage reaching economic proportions were considered to be rare.

A few orchards are reporting a persistent population of San Jose scale (*Aspidiotus perniciosus* Comstock) which appears to be resistant to many of the currently recommended control procedures. Damage was noted on pyracantha, and firethorn plantings in the Lafayette area.

The Shot-hole borer (*Scolytus ruqulosus* (Ratzeburg)) was present but not regarded as an economic problem in properly sprayed orchards.

Woolly apple aphids (*Erisoma lanigerum* (Hausmann)) were very numerous in a few isolated orchards in southwestern Indiana but, as yet, have not reached the status of being a general pest. (Only the aerial forms.)

Livestock Insects

Cattle grub (*Hypoderma bovis* (L.) and *H. lincatum* (de Villers)) activity increased during the summer of 1963 as was reflected in higher counts of grubs in the backs of animals during late winter. Reports of high activity during the summer of 1964 indicate high grub populations will again occur this winter. Almost all activity was due to *H. lineatum* with scattered reports of *H. bovis* as far south as Dubois County.

Face fly (*Musca autumnalis* DeGeer) overwintering populations gave indications of high summer populations during 1964. These high summer populations did not materialize and face fly numbers remained very low until early September when they reached a high of 30 to 35 per head. They remained at this level for only two weeks and then dwindled rapidly. High September face fly populations occurred only in the eastern half of the state, primarily from Highway 40 northward.

Horn fly (*Haematobia irritans* (L.)) populations were much lower in 1964 than during the preceding year. Even on untreated animals, numbers rarely reached 50 per head in the central part of the state. Populations were higher in the southern area of the state during late August, reaching 250 per head for a period of one month.

Black horse fly (*Tabanus atratus* Fabricius) No economically important numbers of the black horse fly were reported in Indiana this year. Two years of drought have apparently reduced populations drastically.

House fly (*Musca domestica* L.) populations were average to low in areas of good sanitation. Livestock barns with poor ventilation built up and maintained high populations from the middle of July until frost.

The stable fly (*Stomoxys calcitrans* (L.)) was encountered early during the summer of 1964 in the north-central area of the state in higher populations than had been reported in the previous year. These populations dwindled until they were average or below for the rest of the season.

Pests of Man and Households

Larger yellow ant (*Acanthomyops interjectus* (Mayer)) Specimens sent in for identification were fewer in number than in previous years.

Box-elder bug (*Leptocoris trivittatus* (Say)) No state-wide trend in the populations of this insect was noted. Populations at any one location fluctuate from year to year. In some places they were almost absent, but in others, the populations were higher than usual.

Cat flea (*Ctenocephalides felis* (Bouche)) Numerous infestations occurred in homes while the occupants were away on vacation. This may occur when dogs or cats are not present to absorb the flea population that develops from eggs and larvae scattered about inside the building.

Clothes moths (*Tinea pellionella* (L.)) and *Tineola bisselliella* (Hummel) Clothes moths continued to decline as important household pests. This may be due to numerous factors, including increased use of synthetic fabrics, improved cleaning and storage facilities, and more effective household insecticides.

Cluster fly (*Pollenia rudis* (Fab.)) Home economics club women report this to be the major pest in many homes and also one among the most difficult to control.

The German cockroach (*Blattella germanica* (L.)) continues to be the most important cockroach in hotels, restaurants and other establishments where food is processed or served. Reports of failure to control this roach with chlordane and conventional insecticides indicates that chlordane resistance has reached a high level.

The Oriental cockroach (*Blatta orientalis* L.) Reports from women attending home economics leader training meetings indicate

that this species is the one most often encountered in homes. Usually referred to by homeowners as a waterbug.

Larder beetle *(Dermestes lardarius L.)* An unprecedented number of infestations occurred in homes during the spring and summer months. Indications are that dead face flies and cluster flies in the walls of these homes may have a contributing factor. The beetles readily develop in decaying animal matter, and in some instances it is believed small animals may have contributed.

Millipedes—Class Diplopoda. Mass migrations into homes were very much less numerous than in previous years. It is possible that dry weather from mid-July on contributed to this reduction.

Picnic Beetles *(Glischrochilus* spp.) These insects were annoying and troublesome for a short period of time in early summer but did not reach the levels of abundance that exsted in 1961, 1962, and 1963.

Strawberry root weevil *(Brachyrhinus ovatus* (L.)) These insects appeared in homes earlier than usual and also in greater numbers. They feed upon the roots of strawberries, evergreens and several ornamental plants and come indoors in search of a place to hibernate.

Subterranean termites *(Reticulitermes* spp.) These insects continue to be the number one pest of man's structures. Pest control operators reported fewer swarms in the spring, but no decline in the number economically important infestations.

Tree, Shrub and Forest Insects

Sod webworms principally *Crambus trisectus* Wlk., were abundant in turf areas throughout the state for the third year in a row. Control measures were necessary to prevent serious damage.

Ambrosia beetles. The following ambrosia beetles were collected in Indiana during 1964 and represent new state records: *Monarthrum fasciatum* (Say) from pin oak, *Xyleborus affis* Eichh. from river birch, and *Xyloterinus poltus* (Say) from silver and red maple were all taken in Dubois County. *Xyloterinus politus* has more recently been found in silver maple in Tippecanoe County. *Xylosandrus germanus* (Bldfd.), first reported from Indiana, Jefferson County, in 1963 has been collected on river birch in Dubois County in 1964.

Bagworm *(Thyridopteryx ephemeraeformis* (Haworth)) populations were lower than usual in most areas of the state, but were locally severe on evergreens around private homes.

The balsam twig aphid *(Mindarus abietinus* Koch) infested Douglas Fir in ornamental plantings in Elkhart. Generally, 1964 populations appeared to be normal.

The black vine weevil *(Brachyrhinus sulcatus* (Fabricius)) was the heaviest in recent years in Lake County. Many nursery and ornamental plantings were heavily damaged and many yew plants killed by the larval feeding. Economic injury was also greater in the metropolitan area of Indianapolis.

The bronze birchborer *(Agrilus anxius* Gory) was again a very serious problem on birch trees. The condition is probably aggravated by the low moisture levels of 1962, 1963 and 1964.

The carpenterworm *(Prionoxystus robiniae* (Peck)) caused considerable damage to oak in Scott County.

Columbian timber beetle *(Corthylus columbianus* (Hopk.)) populations were again very low; this species is clearly a periodic outbreak type and in the trough of population densities.

The cottony maple scale (*Pulvinaria inumerabilis* (Rathron)) was again abundant in northwestern Indiana. The populations in Fowler continues to be severe. There was heavy predation by the twice-stabbed lady beetle *(Chilocorus stigma* (Say)). For the past several years population densities of this insect have been generally low, but an apparent build-up in population has again begun.

Eastern tent caterpillar (*Malacosoma americanum* (Fabricius)) Extremely heavy in southwestern Indiana in the spring. After defoliating the host trees they moved in armies to new sources of food.

Elm leaf beetle *(Galerucella xanthomelaena* (Muller) populations were higher than during the previous two seasons. Adult populations began moving into hibernation quarters in September, earlier than usual. Chinese elm received most damage during the latter part of the summer.

Euonymus scale *(Unaspis euonymi* (Comstock)) populations were more troublesome than for several years. Infestatons of euonymus plantings were common and an infestation of Pachistima was reported from South Bend.

The European pine sawfly *(Neodiprion buoliana* (Schiffermuller)) specimens were very difficult to find during the summer of 1964. Since this insect is known to be sensitive to low temperatures, the severe winters of 1961-1962 and 1963-1964 probably account for the low populations.

Fall cankerworm *(Aisophila pometaria* (Harris)) was of no consequence in 1964.

The fall webworm *(Hyphantria cunea* (Drury)) was unusually heavy on both forest and ornamental trees throughout the state.

Fletcher's scale *(Lecanium fletcheri* (Cockerell)) was of less importance in 1962 than in 1963, but was found on ornamental plantings in Hendricks County.

The gregarious oak leaf miner *(Cameraria cincinnatiella* (Chambers)) population was very low early in the season, but by late summer had recovered and caused considerable browning of the pyramidal English oak foliage at Lafayette.

Honeylocust mite *(Eotetranychus multidigituli* (Ewing) populations were lighter than usual and honeylocust trees held their foliage until frost.

The Judas tree leafhopper *(Erythroneura aclys* McAfee) was again the cause of extensive yellow foliage in south central Indiana on redbud, but populations were lower than last year.

Juniper tip midge *(Oligotrophus* sp.) was of little concern in 1964, probably because of a high parasite population.

A leafroller (*Tortrix pallorana* Rob.) which for several years badly damaged new pine plantings, was barely noticeable during the growing season of 1964.

The locust leafminer *(Chalepus dorsalis* (Thunberg)) was of no consequence in 1964. However, spotty infestations were reported from the southern part of the state.

The magnolia scale *Neolecanium cornuparvum* (Thro)) was noticeable on magnolia trees in several areas of the state during August.

Maple bladder gall *(Vasates quadripedes* (Shimer)), a frequent pest of silver maple trees, was of less importance than usual in 1964.

The maple petiole borer *(Caulocampus acericaulis* (MacGillivary)) caused partial foliation of hard maple trees in Bourbon, Marshall County in late May.

Mimosa webworm (*Homadaula albizziae* Clarke) populations of the first generation were much lighter than usual throughout Indiana, but by mid-August the population had reached normal levels and many honeylocust trees were severely webbed and brown.

Nantucket pine moth (*Rhyacionia frustrana* (Comstock)). Of no importance in 1964.

Oak kermes *(Kermes* spp.) appears to be increasing slightly over the state, but was of no economic importance in 1964.

The oak succulent gall *(Adricus palustris* O.S.) was again important in the pocket area of the state were it damaged ornamental plantings of pin oak.

The oystershell scale *(brown race) (Lepidosaphes ulmi* (L.)) continued to be a serious problem on many silver maple trees and other ornamental trees and shrubs. Heavy populations were noted to severely damage or kill the host plants.

The pales weevil *(Hylobius pales* (Herbst)) continues to cause trouble in pine plantations in south-central Indiana. It was reported from Jefferson and Jennings Counties for the first time.

The pine bark aphid (*Pineus strobi* (Hartig)) was noticeable on the trunks of pine in Christmas tree plantations in LaPorte County, but apparently caused little damage. In general, populations of this pest were lower than in the previous two years.

Pine needle scale *(Chionaspis pinfoliae* (Fitch)) has begun to appear in pine plantations throughout the state. Thus far only a few individual trees are heavily infested, but this could be an explosive situation.

A pine weevil *(Pissodes affinis* Rand) continues to build up in the stumps of cut-over Christmas tree plantations. These heavy populations will then damage pine transplants.

Privet thrips *(Dendrothrips ornatus* (Jablonowski)) caused yellowing and defoliation of privet hedges at Lafayette.

The rose chafer *(Macrodactylus subspinosus* (Fabricius)) adults caused considerable damage to peonies in Lake, Elkhart and Wabash counties.

The rose slug *(Endelomyia aethiops* (Fabricius)) was damaging to neglected rose plantings and rambling roses seemed to be particularly susceptible. However, in general populations were lower than normal.

The smaller European elm bark beetle *(Scolytus multistriatus* (Marsh)) continues to be important because it is the vector of Dutch

elm disease and is spreading the disease in northern Indiana. However, populations in 1964 were generally lower than normal.

The spruce spider mite *(Oligonychus ununquis* (Jacot)) This arthropod was again heavy on spruce and other needled evergreens throughout the state. Many requests for assistance in its control were received.

Sycamore lacebug *(Corythucha cillata* (Say)) was of little consequence in 1964.

The tea scale *(Florinia theae* (Green)) was reported infesting rhododendrons in LaPorte and Elkhart counties.

The terrapin scale *(Lecanium nigrofasciatum* Pergande) infested ornamental sugar maples at Grabill.

The tulip tree callous borer *(Euzophera ostricolorella Hulst)* damaged shade tree plantings in the Plainfield and Scottsburg areas.

Tulip tree scale *(Toumeyella liriodendri* (Gmelin)) populations were the cause of considerable concern on shade and ornamental trees again in the summer of 1964. This pest seems to be moving into the forest areas of the state and may cause some damage in the future.

Twig girdler *(Oncideres cinqulata* (Say)) This insect attacked hickory shade trees in Hamilton County. Reports of spotted injury were received from throughout the state.

Vein pocket gall *(Itonida* spp.) This insect was much less troublesome on pin oak than in previous year. However, in the pocket area of the state, populations appear to be gradually increasing.

The Zimmerman pine moth *(Dioryctria zimmermani* Grote) continues to build up in the northern half of Indiana. Considerable damage was reported from Marion County.

Maintenance of Fruit Insect Cultures at Vincennes, Indiana

MERRILL L. CLEVELAND, Entomology Research Division,
Agr. Res. Serv., U.S.D.A., Vincennes, Ind.[1]

Introduction

It is my intent in this paper to consolidate into one report the methods employed by personnel at the Vincennes fruit insects laboratory to maintain cultures of various fruit insects important to the deciduous fruit growers of Indiana. Culturing insects in large numbers is becoming more and more important in all research leading to insect control. At the Vincennes laboratory supplies of codling moth (*Carpocapsa pomonella* (L.), *red-banded leaf roller* (*Argyrotaenia velutinana* (Walker)) and the two-spotted spider mite (*Tetranychus telarius* (L), sufficient to meet testing needs at the laboratory, are reared under constant temperature and humidity. Larvae of the codling moth and red-banded leaf roller are now reared exclusively on artficial diets. Two-spotted spider mites, both phosphate-resistant and nonresistant strains, are maintained on lima bean foliage. Recent experiments concerning an artificial diet to support populations of the lesser peach tree borer (*Synanthedon pictipes* (Grote and Robinson)) have proved partially successful. The details of the rearing procedures for the above insects follow.

Codling Moth

The basic artificial diet used for rearing codling moth was developed by Robert E. Redfern (1964-b), formerly of the Vincennes staff. The constituents of this diet, sufficient for 150 cups, follow:

Apple seeds	30 g.	Ascorbic acid	10 g.
Dried apple	60 g.	Linseed oil	10 ml.
Sugar	60 g.	Agar	20 g.
Soybean protein	60 g.	Water (140° F.)	1,100 ml.
Wessons' salt	12.5 g.	Vitamin solution	12.5 ml.
Yeast	12.5 g.	(Vanderzant & Davich (1958))	
Glycine	1.25 g.		
Cysteine	0.625 g.	KOH (10% sol.)	37.5 ml.
Cholesterol	.625 g.	Mold inhibitor	22.5 ml.
Alphacel	30 g.	(Redfern 1963)	

After mixing these ingredients in a high-speed blender, ¼ ounce of the medium is dispensed into a 1-ounce plastic cup. Before the medium has solidified, three apple seeds are placed in each cup. After the medium has cooled at room temperature overnight, two newly-hatched codling moth larvae are transferred to it; a pasteboard cap is placed on the cup, and the cups are stored in a rearing room maintained at a temperature of 80° ± 2° F. and a relative humidity of 55% ± 5%. The room is continuously lighted by four 40-watt fluorescent bulbs. After approximately 28 days, caps are removed to allow

[1] In cooperation with the Indiana Agricultural Experiment Station.

adult emergence. Currently, from 60 to 70% of the larvae placed on the medium emerge as adults. Eggs are obtained by confining 100 adults (random collection of males and females) in waxed cylindrical pasteboard cartons. These "oviposition cages" measure 3 x 6 inches. Moisture is provided by inserting a cotton-plugged 1-inch shell vial filled with water into the side of the cage. Three fresh pear twigs (½ x 5 inches) are placed in each cage to provide a resting place and increased oviposition area. Moths are removed after 5 days, and the cages and twigs are then refrigerated at 48° F. Hatch of the oldest eggs deposited occurs within 3 hours after removal from the refrigerator.

Red-Banded Leaf Roller

The diet we are currently using to rear the red-banded leaf roller was described by Redfern (1964-a) and represents a simplification and improvement of a medium which he described earlier (Redfern 1963). The constituents of this diet, sufficient for 320 cups, follow:

Alfalfa meal	250 g.
Agar	20 g.
Mold inhibitor	52 ml.
Vitamin solution	24 ml.
Water	2,000 ml.

The mixing procedure is similar to that used for codling moth medium. After the medium is placed in 1-ounce plastic cups, it is marked with a dissecting needle to afford the leaf roller larvae a hiding place. When this mixture has cooled and dried overnight, four newly hatched leaf roller larvae are placed on each cup and the cups capped. They are then placed in a rearing room, maintained at the same temperature and humidity given for the codling moth. Four days after the first pupation is noted, caps are removed for adult emergence. Approximately 44 days are required from egg deposition to the adult stadium. About 75% of the larvae placed on the medium emerge as adults. The techniques we use to obtain red-banded leaf roller eggs are similar to those for codling moth.

Two-Spotted Spider Mite

The techniques we use to rear two-spotted spider mites at this laboratory were given by Cleveland (1960). Baby Fordhook lima beans are grown in sand-filled plastic cups, approximately 2½ inches in diameter and 3 inches high. The plants are watered lightly each day, but no nutrients are added. The cups are perforated on the bottom to avoid excess water accumulation. In the rearing room in which these plants are kept, the temperature is maintained at 82° ± 2° F. and relative humidity at 65% ± 5%. The walls and ceilings are painted white. The room is continuously lighted with 18 40-watt fluorescent tubes. The bean leaves used at this laboratory will support a population of more than 500 mobile mites for a short time. Under these conditions, the mites complete a life cycle in 9 to 12 days.

Lesser Peach Tree Borer

In preliminary experiments we have successfully reared larvae of the lesser peach tree borer to adulthood on an artificial diet consisting of the basic codling moth diet described above, with the addition of alfalfa meal and peach wood shavings. Data are incomplete at this time, but we are currently realizing about a 50% return of adults from larvae fed on this diet. The temperature-humidity conditions are approximately the same as those used with codling moth. Newly-hatched larvae have been collected in the field for most of these tests. On three occasions eggs deposited by females in the laboratory hatched, and the resultant larvae were fed on the medium. To date, we have encountered no diapause problems.

In the near future we anticipate studying diets to maintain stink bug, plum curculio (*Conotrachelus nenuphar* (Herbst)), apple maggot (*Rhagoletis pomonella* (Walsh)), oriental fruit moth (*Grapholitha molesta* (Busck)), and, perhaps, apple aphids. We thus hope to have supplies of different insects available so we can study the ones of importance to the deciduous fruit industry of this area.

Literature Cited

1. Cleveland, M. L. 1960. Laboratory rearing and testing technique for the two-spotted spider mite. Proc. N. C. Branch E.S.A. XV:66-7.
2. Redfern, R. E. 1963. Concentrate media for rearing red-banded leaf roller. J. Econ. Entomol. **56(2)**: 240-1.
3. Redfern, R. E. 1964-a. An improved medium for rearing red-banded leaf roller. J. Econ. Entomol. **57(2)**:296-7.
4. Redfern, R. E. 1964-b. Concentrate medium for rearing the codling moth. J. Econ. Entomol. **57(4)**:607-8.
5. Vanderzant, E. S. and T. B. Davich. 1958. Laboratory rearing of the boll weevil; A satisfactory larval diet and oviposition studies. J. Econ. Entomol. **51(3)**:288-91.

GEOLOGY AND GEOGRAPHY

Chairman: JOHN FRASER HART, Indiana University

JOHN B. PATTON, Indiana University, was elected chairman for 1965

ABSTRACTS

The Cretaceous and Indiana. D. E. OWEN, Indiana State University. —The distribution of once very widespread marine and nonmarine Cretaceous deposits in North America has been greatly reduced by later erosion. Scattered outliers which have been recognized from time to time generally occur in freakish locations where there was unusual protection from erosion. Cretaceous fossils reported from the glacial drift of Iowa, Illinois, and Missouri indicate that Cretaceous seas extended considerably farther east than is shown by bedrock exposures. Gravels, sands and other deposits occur in Wisconsin, Minnesota, Iowa, Illinois and possibly Kentucky which have not yet yielded fossils but which are thought to be of Cretaceous age. It seems probable that these are fluvial deposits associated with a major outpouring of clastics and a related regression (Newcastle unit) near the end of Early Cretaceous time. Similar deposits may exist in Indiana. Mapping of the pre-Cretaceous paleogeology and Cretaceous onlap zero edges according to somewhat revised correlations in states west and northwest of Indiana shows progressive burial of an old erosion surface by units both marine and nonmarine. Similar onlap, which may have reached Indiana, is shown by the Late Cretaceous of the Gulf Coast Embayment.

Development of a Karst Valley in Monroe County, Indiana. RICHARD L. POWELL, Indiana Geological Survey.—A karst valley in western Monroe County has developed where the surface stream of a former southward-flowing tributary of Indian Creek was diverted westward underground into valleys that are minor tributaries to Richland Creek. The diversion of water from the karst valley was caused by a lower base level along Richland Creek. This subterranean diversion was channeled through three multi-level cavern systems, each with mapped passages in excess of 1 mile, that lie beneath the ridge of clastic rocks which separated the surface drainage of Indian Creek and Richland Creek. These caverns were dissolved within the westward-dipping limestone strata which are exposed in the floor of the valley and along Richland Creek. Segments of the karst valley presently drain into these three known cavern systems. Abandoned levels in the caverns and depositional and erosional terraces in the karst valley and in Richland Creek indicate that there were several distinct stages during the diversion of surface drainage of the karst valley to subterranean drainage. These erosion levels developed during the late part of the Tertiary Period and during the Pleistocene Epoch.

The End Moraines of the Cartersburg Till Member in Central Indiana.[1] WILLIAM J. WAYNE, Indiana Geological Survey.—The main advance of glacial ice into central Indiana during Wisconsin time had two distinct pulsations within a span of about 1,000 years. About 21,000 years B.P. the earlier of these reached the position commonly referred to as the Wisconsin glacial boundary, where a segmented moraine, generally identified as the eastward extension of the Shelbyville Moraine of Illinois, was built. After this brief moraine-building episode the ice of the East White Sublobe melted somewhat and then readvanced to a new position a few miles short of its previous extent. The till sheet left by the second advance is the Cartersburg Till Member of the Trafalgar Formation. The end moraine at the edge of the Cartersburg has never received an acceptable name, although Leverett regarded it to be a continuation of the Champaign Morainic System of Illinois.

A distinct, but narrow, ridge from a point northeast of Rushville where it separates from a morainic complex near the Ohio State line, this moraine trends southwestward toward Columbus and then northwestward as a broad massive rise through Trafalgar and Bargersville. The moraine becomes a high distinctive ridge past Danville and seems to split into two crests, one on either side of Crawfordsville, where the Champaign Moraine disappears beneath it. North of Attica, the double moraine can be traced northward to the place where it also crosses the Bloomington Moraine. It becomes indistinct north of the intersection with the Chatsworth Moraine 10 miles south of Fowler.

Many kames characterize this end moraine, and several large outwash plains emerge from it. Exceptionally rugged morainic topography in Montgomery County makes the area around Crawfordsville an excellent place to examine the moraine and its overriding relationships with the Champaign and Bloomington Moraines of the Lake Michigan Lobe.

A second end moraine on the Cartersburg till stands as a massive ridge from northeastern Shelby County to northeastern Henry County, where it merges with the westward extension of the Farmersville Moraine of Ohio. This moraine was considered by Leverett to be a continuation of the Bloomington Morainic System of Illinois, but the Bloomington, like the Champaign, disappears beneath the Cartersburg till in western Indiana. Some of the most rugged and distinctive topography of this morainal segment is in the area just west of Knightstown. As very little morainic topography is present in central Indiana, no logical boundary can be drawn to tie this morainal segment to any other recognizable moraines farther west in the State.

[1]Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

Population Concentration in Indiana

JOHN FRASER HART, Indiana University

The size and character of the population vary enormously from one place to another. This is a fundamental fact of human geography. One of the basic objectives of human geography must be a better description and understanding of geographical variations in population density. Toward this end, I have been using the state of Indiana as a laboratory. In years past I have discussed with this group the distribution of the rural nonfarm population (1), migration and population change (2), rural population density (3), changing census concepts of rural population (4), and the major components of population distribution (5).

This paper is an outgrowth of the preparation of a series of maps of the distribution of the population of Indiana, and its principal residential components, as revealed by the 1960 Census of Population. These maps are based on unpublished data for minor civil divisions and census tracts (6). Separate maps have been prepared for the density, by township, of the total population, the urban population, and the rural farm population. The rural nonfarm population has been divided into those people who live in incorporated places of less than 2,500, which are here called "non-urban places," and the remainder of the rural nonfarm population.

The density maps of urban population and of rural nonfarm population outside incorporated places have remarkably similar geographical patterns. These are not the patterns of uniform regional density with which geographers are most familiar, however. They are what I have previously referred to as "point-oriented" patterns (5). Isolated townships or small groups of townships with very high densities are separated by groups of townships with relatively low but uniform density.

I have previously demonstrated a similar congruency of pattern at the county level, and concluded that the distribution of the urban population appears to be an important determinant of the distribution of the rural nonfarm population outside incorporated places (1). The finer grid provided by data at the township level demonstrates this effect far more forcibly. It is my purpose here, therefore, to examine the relationship between population concentrations in urban places and the distribution of various residential components of the population at the township level.

Concentrations of Population

The population of Indiana is indeed remarkably concentrated within a few townships. More than ten percent of the people of Indiana live in the two most populous townships, which occupy only one-third of one percent of the state's total area. The seven most populous townships occupy only one percent of the state, but they contain more than one-quarter of all the state's people. And eighteen townships,

which occupy less than two percent of the total area, have two-fifths of all the people.

The twenty most populous townships are all associated with metropolitan areas or major cities. Five are in and around Indianapolis, three are in the Gary-Hammond area, two are at Evansville, and one each is at Fort Wayne, South Bend, Muncie, Terre Haute, and New Albany. The non-metropolitan centers associated with most populous townships are Anderson, Kokomo, Richmond, Lafayette, and Elkhart, each of which has a population of more than 40,000 people.

If the link between metropolitan/urban areas and population concentration is so close, one might reasonably ask why we bother with township data when we might more easily use data for the metropolitan/urban areas defined by the Bureau of the Census. For example, fifteen of the twenty most populous townships are within the eight Urbanized Areas of Indiana. These eight Urbanized Areas have a total population of 1,891,765 people, or 186,826 more than the fifteen townships.

The answer is provided by the other five most populous townships, which contain 256,619 people, or 33,608 more than the five cities of Anderson, Kokomo, Richmond, Lafayette, and Elkhart. When one compares data for smaller cities with the data for the townships within which they are located, it becomes increasingly apparent that the population concentration associated with the city has spilled over into the adjacent township. We must therefore use data for townships rather than for incorporated places if we wish to understand the relationship between population concentrations and population distribution.

The reason, of course, is the simple fact that most cities have outgrown their political boundaries, and the real city covers a territory considerably larger than the area within the city limits. The Bureau of the Census is fully aware of this fact, and it has defined Urbanized Areas or "real city" areas, for cities which have 50,000 people or more (7). The Urbanized Area consists of the city plus an urban fringe of closely settled territory, which may include both incorporated places and unincorporated areas.

The entire population of the Urbanized Areas is classified as urban. In 1960 the urban fringes, or overspill areas, of the eight Urbanized Areas in Indiana had 14,567 people in incorporated places of less than 2,500 persons and 252,923 people who lived in unincorporated areas. But for the fact that they lived on the closely settled fringe of a city of 50,000 or more, all of these 267,490 people would have been placed in the rural nonfarm classification by the Bureau of the Census.

Although overspill is not restricted to cities of 50,000 or more, the Bureau of the Census unfortunately has not been able to delimit Urbanized Areas for cities of less than 50,000 people. The fringe population of these cities thus remains in the category of rural population. For example, a person who lives only a few yards outside the limits of a city of 49,999 people is classified as a rural person for census purposes. He automatically becomes an urban person when the population within the city limits reaches 50,000 people, or when the city expands its limits to annex the area within which he lives.

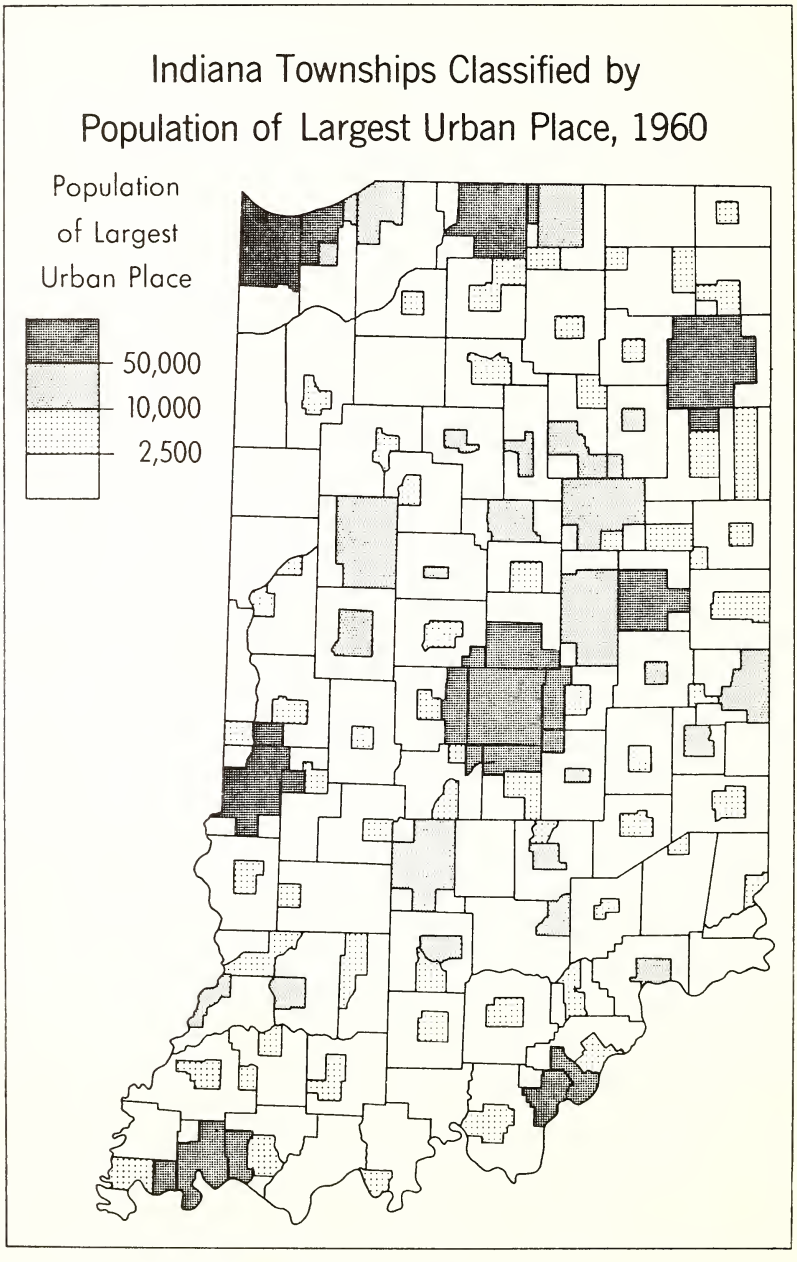


Figure 1. Classes of Indiana townships

Distribution of the Residential Components

The size of the largest place within each township provides a basis for grouping Indiana's 1,009 townships into four categories (Fig. 1). Each township is placed in the highest category for which it can qualify. The first category includes townships which contain some part of an Urbanized Area, plus one tier of contiguous townships. The second includes townships which contain some part of a city of ten to fifty thousand people, plus the contiguous tier. The third includes townships containing a city of 2,500 to 10,000 people, while the fourth and lowest category contains no place as large as 2,500.

For convenience, these groups might be thought of as metropolitan, city, town, and rural townships. The metropolitan group includes 102 townships and 10.1 percent of the state's land area. The city group has 83 townships and 8.3 percent of the area, while the town group has 78 townships and 9.8 percent of the area. The remaining 746 rural townships have 71.8 percent of the state's area.

The total population of all townships in each category has been tabulated in terms of its four residential components: urban, non-urban places, remaining rural nonfarm, and farm (Table 1). The distribution of these residential components in the different size-of-largest-place township categories must be examined from three distinct viewpoints:

TABLE 1

Distribution of the Population, by Place of Residence, when Townships Are Grouped by the Size of Their Largest Urban Place

Place of Residence	Size of Largest Urban Place: 50,000 or more	10,000 to 50,000	2,500 to 10,000	Townships with no Urban Place	The State
	Number of Persons				
Urban	1,920,860	653,059	336,372	———	2,910,291
Rural nonfarm	300,255	233,756	109,701	622,974	1,266,686
Non-Urban places	30,479	42,825	13,894	245,256	332,454
Remainder	269,776	190,931	95,807	377,718	934,232
Rural farm	47,259	41,485	49,358	347,372	485,474
Total	2,268,374	928,300	495,431	970,346	4,662,451
	Percentage of Total for Size of Place				
Urban	84.7	70.4	67.9	0.0	62.4
Rural nonfarm	13.2	25.1	22.1	64.0	27.2
Non-Urban places	1.3	4.6	2.8	25.2	7.1
Remainder	11.9	20.5	19.3	38.8	20.1
Rural farm	2.1	4.5	9.9	36.0	10.4
Total	100.0	100.0	100.0	100.0	100.0
	Percentage of Total for Place of Residence				
Urban	66.0	22.4	11.6	0.0	100.0
Rural nonfarm	23.8	18.5	8.7	49.0	100.0
Non-urban places	9.2	12.9	4.2	73.7	100.0
Remainder	28.8	20.4	10.3	40.5	100.0
Rural farm	9.7	8.5	10.2	71.6	100.0
Total	48.7	19.9	10.6	20.8	100.0

first, density variations, in terms of numbers of persons per square mile; second, the distribution of the residential components within each size of place category; and third, the concentration of the residential components in the different size of place categories.

Two aspects of the density distribution merit attention. First, although the urban and rural nonfarm densities decline predictably with size of place, the farm population density is remarkably uniform in all four size categories. Secondly, the city townships have an appreciably greater non-urban place density than the metropolitan townships. Many places on the city fringes have incorporated to avoid annexation. Such places are included in the Urbanized Areas of cities of 50,000 or more. The Indianapolis Urbanized area, for example, has 8,905 people living in incorporated places of less than 2,500, but these people are classified as urban because they are within the Urbanized Areas. They would be classified as rural nonfarm people if they lived on the fringe of a city of less than 50,000 people for which no Urbanized Area had been defined.

Turning to the distribution of residential components within each size of place category, it is notable that at least two-thirds of the people in each urban category are city-dwellers, and most of the rest are in the rural nonfarm category (Table 1). The lower percentage of rural nonfarm people in metropolitan townships is due in part, once again, to the existence of Urbanized Areas. Those people who would be classified as rural nonfarm if they lived on the fringe of a city of less than 50,000 are classified as urban because they live within the Urban Fringe of the urbanized area.

Less than two-fifths of the people of rural townships are farmers, whereas a quarter of these people live in incorporated places which are not considered urban because they have less than 2,500 people (Table I). Roughly two-fifths of the people of rural townships apparently are rural nonfarm people who live in the open country, but this might be misleading because of the vagaries of incorporation (8). A considerable, but indeterminate, proportion of these people actually live in villages which have chosen not to incorporate. The failure of these villages to incorporate means that no separate data are published on the size of their population.

Metropolitan townships have a disproportionate share of the urban and remainder rural nonfarm population (Table 1). When one remembers that these townships occupy only ten percent of the state's land area, it is obvious that they also have almost their share of the non-urban place and farm population. The city townships also have their proportionate share of each residential component of the population, and so do the town townships, apart from non-urban places. This low value for non-urban places may be due to the fact that a town of 2,500 to 10,000 is large enough to stifle competition from other places within its township, yet not large enough to have generated any dormitory villages.

The rural townships, which occupy 71.8 percent of the state, have their fair share by area of the rural farm people and the non-urban place people. At first glance they also appear to have more than their

share of the rural nonfarm population outside incorporated places, but one must remember that the townships in each of the first three size-of-place categories occupy roughly ten percent of the state's area. In terms of land area the row for remainder rural nonfarm would read ten-ten-ten seventy, whereas the actual percentages are thirty-twenty-ten-forty.

Six conclusions may be drawn from this examination of the relationship between population concentrations and the distribution of the various residential components of the population of Indiana in 1960:

1. Both the density and "intensity" (9) of the urban population increase with increasing size of place.

2. The density and intensity of the rural nonfarm population outside incorporated places also increase with increasing size of place.

3. The failure of the total rural nonfarm population to increase proportionately in metropolitan townships is largely due to the fact that a quarter of a million rural nonfarm people who live in Urbanized Areas are classified as urban people by the Census.

4. Townships containing cities of ten to fifty thousand people have a disproportionately large non-urban place population because Urbanized Areas are not delimited for cities of this size.

5. Unlike other residential components, the farm population has a relatively uniform and even geographic distribution.

6. The relationship between the geographical distribution of the farm population and the non-urban place population appears close enough to warrant further investigation.

These conclusions lead to one final summary conclusion: any attempt to describe, understand, and explain the complex geographical distribution of the population must be based in large measure on a full comprehension of patterns of population concentration.

Literature Cited

1. Hart, John Fraser. 1956. The Rural Nonfarm Population of Indiana. Indiana Academy of Science **65**:174-179.

2. ————————. 1957. Migration and Population Change in Indiana. Indiana Academy of Science **66**:195-203.

3. ————————. 1959. "Rural Population Density in Indiana." Indiana Academy of Science **68**:218-224.

4. ————————. 1960. Census Concepts of Rural Population in Indiana. Indiana Academy of Science **69**:249-253.

5. ————————. 1962. Some Components of Population Distribution in the Middle West in 1950. Indiana Academy of Science **71**:210-218.

6. U. S. Bureau of the Census. 1962. U. S. Census of Population: 1960. Special Tables PH-2 and PH-3, Unpublished Sample Population and Housing Data for Minor Civil Divisions from the Census of Population and Housing.

7. U. S. Bureau of the Census. 1961. U. S. Census of Population: 1960. Vol. I, Number of Inhabitants: Report PC(1)-16A, Indiana, vi-vii.

8. Hart, John Fraser, and Neil E. Salisbury. 1965. Population Change in Middle Western Villages: A Statistical Approach. Annals of the Association of American Geographers **55**: (in press).

9. Hart, John Fraser. 1960. The Changing Distribution of the American Negro. Annals of the Association of American Geographers **50**:242-266, cf. p. 246.

Is Indiana Becoming Overpopulated?

Stephen S. Visher, Indiana University

When few people lived in Indiana, nearly all of them were poor. For several generations, increases in population led to higher standards of living for most of the people. This was made possible because with more people, there were more workers, more varied abilities, and also improved education, transportation, health and equipment with which to work. Decade by decade also more of Indiana's resources were put to productive use. Now resources which were unused or only slightly used when Indiana became a state in 1816 contribute greatly to Indiana's prosperity. "Progress Made in Increasing Indiana's Human Resources" (*Proceedings, Indiana Academy of Science*: Vol. 70, pp. 189-193; 1961) discusses at some length several of these factors. It concludes that Indiana's human resources in 1960 could be conservatively evaluated at more than 45 billion dollars. This is more than the money value of all of Indiana's land, buildings, roads, railways, equipment, etc., and thousands of times as valuable as were Indiana's 100,000 people and land in 1816.

The vast increase in the value of Indiana's human resources was accomplished partly at the expense of Indiana's forests; eroded soil; considerable coal mined or rendered practically useless; much petroleum and natural gas used or wasted; and a drastic depletion of most wild life—birds, game animals and fish.

Various scenic resources also suffered badly during recent decades as results of the fast expansion of inadequately planned "urban sprawl," auto junk yards, and the misuse of Parks and other recreational resources, which are inadequate for the present population. Pollution of streams, lakes, and the air over several cities gives appalling evidences of deterioration associated with great population increases.

Although Indiana continues to be a relatively prosperous state, many hundreds of thousands of Indiana's present population are "unemployed or inadequately employed." This is in contrast to "the good old days" when almost any willing worker could find worthy work. Many young people are especially handicapped now, partly because they possess inadequate ability, vigor and desire or motivation to obtain the education now needed. There still are opportunities for people possessed of various skills obtained from special training, facilitated by appropriate talents. But, as a direct result of the great increase in population, there is increasing competition for jobs.

No longer is there opportunity for many workers on Indiana farms, which have, during the agricultural revolution of recent years, required expensive equipment, fertilizer and skilled management rather than strong, willing workers.

The industrial revolution, with its drastically increased use of complicated equipment and automation, has greatly decreased work opportunities for people who do not have special skills.

Unfortunate indeed are the many people who lose their jobs as a result of innovation and automation, and who are unable to train themselves for another job.

Every Hoosier knows that there is a great increase in the percentage of somewhat elderly people, and that this percentage is growing rapidly. Many positions are restricted now to people younger than 45. Few people can obtain worthy work in Indiana now if they are much older than 55. Many even very able people are forced to surrender their job at 65, as there are so many younger people ready to take them.

Instead of expecting "better times" to follow the "population explosion," it is logical to urge not only the obtaining of better education but also "family planning" and "birth control" so that each new child is not only strongly wanted by its parents but also has a good prospect of having a reasonably bright future because it can be adequately reared and educated.

Overpopulation certainly is approaching rapidly in much of Indiana, if it is not already here. Indeed, already the state and its cities are having serious difficulties in providing the much better education now needed, the more adequate facilities required for proper health and the recreational and transportation facilities required by our present population. What will we do when Indiana's population increases by another million, as it almost surely soon will do? Our schools, highways, parking places are already crowded. Within the next five years the population pressure will increase sharply. Of course we hope that this population increase will not produce a decline in the quality of life and services.

There clearly is need now in Indiana for more people who possess distinctly better than average mental, physical and emotional ability or vigor, superior education and earnestness. Such people can contribute significantly to Indiana's welfare. Indiana certainly is not now overpopulated with well qualified people. There are so many things which need to be done, but which require special skills that we could use millions more "superior" people.

Better quality, not great population total, is what is needed. How can this need be filled?

Most of those who read this realize that there are many difficult problems as to Indiana's people, including its Negroes, slum dwellers, and those who are deficient in ability, vigor, education, or are "too old." Wise planning, including birth control and a sharp reduction in "teen-age" marriages, surely are needed. We should plan far more wisely that we have planned. Each one of us can assist in this planning and the problems that face us are so serious that we should assist.

Manufactural Geography of Greater Blue Island, Illinois[1]

(A Study in Industrially Saturated Space)

ALFRED H. MEYER and BEN LAIR, Valparaiso University

"Of Chicago but not in Chicago" might well characterize the Blue Island manufacturers' geographic site and situation. As part of metropolitan Chicago, the manufacturing establishments share the benefits of its converging rail and road transportation patterns, its concentrated labor pool, its expanding market for particularly the fabricated metal products specialized in by the Blue Island area manufacturers. But as apart from neighboring Chicago, here was a site of lower taxes, lower costs of land, and especially more room for the initial factory space or future expansion facility. Nearly 100 per cent of respondents to our questionnaire declare the growth potential of the area as a prime reason for locating here.

Now, ironically in the geographic process of environmental change, many industrial plants in Blue Island itself find themselves unable to extend their premises, and new sites are practically unavailable for relocation. And since the city, unlike the other industrial Calumet communities studied (e.g., Chicago Heights, to the south), has not incorporated community planning in its otherwise outstanding historic development, it now has become industrially "saturated" and can offer only a very few zonally restricted sites to industry almost confined to the "limited" classification.

Areal Antecedent Attractions

In 1834, the first-known white settler in the area built a crude log hut on the edge of a prominent "hill" near the banks of Stony Creek. This hill, some twelve miles south of the youthful town of Chicago, is oval-shaped and measures about six miles long by two miles wide originally covered with a thick growth of trees. During glacial times, this till ridge was a true island in the ancient Lake Chicago which covered the area (1). In 1835, the historic Rexford Tavern was built on the south end of the "Island" on the Vincennes Trace at or near the junction of seven prominent Indian trails. The Vincennes Road, a relict section of which appears on the city map, was the leading travel route in pioneer days connecting Vincennes with Chicago, and may be regarded as the precursor of Illinois 1 highway (2). "The Blue Island House," as it was called, became an immediate success and many travelers enjoyed the panoramic view of the surrounding plain from its front porch.

---

[1]Greater Blue Island, as here comprehended, includes the area identified on the accompanying map—the contiguous section of Blue Island, neighboring Posen and Dixmoor on the south, and the Alsip area to the west. The survey represents the seventh of the series of Calumet industrial geography studies, the other six (those of Michigan City, LaPorte, Gary, East Chicago-Whiting, Hammond, Chicago Heights) having been previously published in the Proceedings. Grateful recognition is due all the industrialists who have so generously co-operated in supplying questionnaire-interview data which have made possible an approximate 50 per cent categorical inventory of the 61 mapped plants of the area; also thankfully acknowledged are the sources cited.

Slowly, but in steadily growing numbers, pioneer farmers began taking advantage of the rich black soil on the flanks of the ridge and the low-lying prairie surrounding the ridge. With the farmers came their supporting craftsmen, a blacksmith shop being the first industry to be established (1837). Hardware, drug, and clothing stores rapidly grew to fulfill the needs of the farmers and herders who passed through on their way to and from the great markets and stockyards which were already operating in Chicago.

The till ridge on which the settlement was growing, influenced the development of the small town's first major industry, the breweries. By 1860 there were four breweries which had dug tunnels into the sides of the hill for cooling their brew (3). Among other industries which prospered for a time was a grist mill on the Little Calumet River which operated until 1875 when farmers blew up the dam because of flooded fields. Small stone quarries supplied local needs as did artisans who made bricks by hand from local clay until machinery put them out of business. Today, clay pits and brick plants are dominant landmarks in the area (see map).

The low fertile lands surrounding Blue Island were a curse as well as a blessing. The black soil attracted many farmers, particularly those of German descent, who soon outnumbered the pioneer American settlers. Much of Blue Island's success has been attributed to the honesty and hard work which these Germans brought to the area (4). There were also many swamps, remnants of the incomplete drainage that followed the recession of glacial Lake Chicago, creating stagnation, and probably causing the great plagues of ague and cholera which swept the area in the 1840's and 1850's. Some of these marshes still remain as an obstacle to the expansion of modern industry.

The industrial development of Blue Island, one could say, rolled into the 20th Century on the steel wheels of the railroad. Mayor John M. Hart reportedly estimates that today railroaders occupy at least 40 per cent of the city's 5000 homes. The Rock Island Line first opened a passenger station in 1852, and four other railroads now offer their services to the city. This large number of railways serving a community of about 20,000 can be explained by its proximity to the city of Chicago and the convergence of many railroads on this midwest metropolis. This has allowed the birth of heavy industries in the area which have to depend in whole or in part on railway service for delivery of both raw materials and bulky finished products. Ample industrial sidings have been constructed, especially by the Indiana Harbor Belt Railroad, which links with every railroad in the Calumet Industrial District. In addition to the two railroads already mentioned, the Chicago & Grand Trunk Western, the Baltimore & Ohio Calumet Terminal Railroad, and the Illinois Central Railroad all offer their services to the city. How the industries are space-related to the rail net is figured in the accompanying map.

In 1920, a drainage and shipping canal was completed from the Little Calumet River at Blue Island to Lockport, Illinois, on the Des Plaines River about thirty miles to the southwest. The Army Engineers are now widening this canal from the original 60 feet to 225 feet

and building new bridges with more clearance (5). When this waterway was built, its primary purpose was to prevent the pollution of Lake Michigan with sewage, and only secondary was the idea of navigation. However, this widening presages the increasing importance this link serves in the "Lakes to Gulf Waterway" project (6).

Classified Manufacturing and Its Spatial Relationships

Sixty-one manufacturing industries have been mapped in the area, five of which have been placed in the miscellaneous category. The other fifty-six are classified in twelve categories, as indicated on the map, following the general type of pattern classification as used by the Federal government (7).

The dominant type of manufacturing by far is fabricated metal products—some twenty-one plants, constituting about one-third of the classified industries. Others, in general descending order of importance, are: primary metal industries (7); stone, clay, and glass products, (6); machinery (except electrical), electrical machinery and equipment, and chemicals and allied products, (4 each). Among the smaller numerical categories are food products (3), paper and allied products (2), and dental and surgical supplies (2). Petroleum refining, plastic products, and lumber and wood products number one each.

The geographic pattern as a whole is obviously related to the earlier established railway net referred to above. In a later topic the pattern will be analyzed in terms of the modified transport services of trucking. Topographically, the heavier industries and those which are expanding lie around and beyond the edge of the ridge that forms the backbone of Blue Island. The elevation proper features small, mostly consumer-manufacturing firms, which depend on truck transportation.

The mapped distribution pattern suggests a threefold areal differentiation, identified on the map by A, B, and C. The A section, bounded on the north by Broadway and west by the city limits, extends southward beyond the city limits into adjacent Posen and Dixmoor. It is distinguished by its industrial compactness and diversity, embracing almost half of the total plants of the region, and representing 10 of the 13 classifications. It might be thought of as the industrial core, the founding of the establishments dating primarily from 1900 to 1960. Contrastedly, the B section, northern Blue Island, has about half the number of plants found in A, dispersed, and occupying generally much smaller sites. Section C, northwest area, is dominated by large space-demanding industries (e.g., brick manufacturing; petroleum refining; metal fabrication), with wide open spaces still available for occupancy.

Space and Other Primary Locative Factors

The locative factors, reported in the order of frequency of responding single or multiple entries, are as follows: space (60 per cent), market and home site (each 22 per cent), proximity of labor and availability of buildings (each 16 per cent), transportation (12 per cent), raw materials (9 per cent), and taxes (6 per cent). It will be recognized that a number of these involve "regional" considerations, as well as site, which the manufacturer does not always measure in distinctive

areal terms; for example, the "symbiotic" relation of the metal-machine fabricators to the Midwest's mammoth steel producers (see insert map).

The famous Libby, McNeill and Libby Corporation establishment exemplifies the combined geographic influence of site and situation. Coming to Blue Island in 1918, it overshadows all other food-processing plants in the area with its employment of almost 800 workers and an annual income of some $10,000,000 from its canned and bottled food products sold in a nation-wide market. The primary reason for locating here is reportedly "to be close to the truck farms which supply the garden products in good quantity."

Related even more closely to a local natural resource is brick manufacturing. Established in the area (1900) to take advantage of the high quality red clay underlying the "island's" glacial till and the close-in market, the Illinois Brick Company has progressively expanded, now employing over 300 workers and marketing some 50,000,000 bricks annually, primarily in Illinois. Clay quality is here evaluated in terms of chemical content, ease of machining, drying, and burning.

Adequacy of Space and Building Availability

Again and again, "space" is a primary factor emphasized. With vacant land, suitable for expansion, becoming increasingly scarce and expensive in Chicago, well over half of the industrialists emphasized the factor of "room" at reasonable purchase price as a prior consideration for establishing at Blue Island. Thus, the following expressions: "area undeveloped," "appeared to have potential for the future," "and least expensive," "a chance to get away from congested area," "enough space to dispose of acid fumes without bothering home owners." Often building adaptability combined with site availability: "purchase of an earlier plant," "rental of building available," "plant adequately suited to needs when purchased." Local residents would be among the first to recognize this space opportunity.

But industrialists recognize that, however necessary adequate ground and floor space may be, access to market, labor, raw materials and so forth call for efficient transportation facilities. Accordingly, the relative listing of transportation above is obviously misleading, its pre-eminence being no doubt assumed by the respondents as a prerequisite to functioning of the other factors that its specific notation in the questionnaire was simply considered by many as superfluous. And when the transportation factor was actually noted, its efficacy usually was commented upon in the strongest of terms.

Blue Island occupies a unique transportation position. With approximately only 20,000 population, it is served by five major railway lines: The Rock Island; Chicago & Grand Trunk Western; Baltimore & Ohio Calumet Terminal; Illinois Central; and the Indiana Harbor Belt, which links the railroads in the Calumet Industrial District. This unique railway net and its proximity to Chicago is a key factor in Blue Island's historic manufacturing development, but as indicated in the next section, the truck is progressively supplanting the train in an increasing number of instances, even in transporting the heavier commodities.

Transition of Train to Truck Transportation

Despite the fact that the manufactural pattern of the area predominantly calls for transport of heavy raw materials as well as heavy processed materials, many industries in both categories today transport more and more by truck, a trend particularly noticeable within the last ten years,—"up 25 per cent in recent years," as one respondent put it. No wonder, then, that there is increasing traffic concern on the part of city officials of many of the urban and rurban communities through which the large trucks must pass with their heavy loads, especially where there are no satisfactory bypasses of such communities. Naturally also, this increasing heavy truck traffic creates a growing problem of providing enough major highways to accommodate such traffic. Statistical compilation on the category of "transportation of raw material received" shows that not a single firm reported exclusive rail transportation, and only fourteen indicated only partial use of railroads. In the category of "transportation of products shipped out," we note the following: eight establishments employ truck service practically exclusively, and another ten, partially. None report using railways exclusively, and nine indicate partial shipment by rail. In petroleum refining, all raw materials are now virtually imported by pipe lines, and refined products are distributed largely by truck and boat. Railway express, parcel post, and plane transport are employed for specific but rather limited consignments.

Considerations for determining the type of transport used are: costs, speed, convenience of connections between shipper and consumer, specifications for certain types of shipment by customers and the like. "Price," "speed," "service" appear again and again in the tabulated entries. Several report that trucks are definitely the most "convenient" (contact) form of transportation; a few indicate that lack of rail siding calls for truck shipment. Recalling, then, that the originally established railroad net of Blue Island was by far the primary factor, along with available factory sites, in the establishment of this most important manufacturing center, one cannot help but wonder what the destiny of railways generally will be with increasing loss of freight to truckage.

The comparatively recent construction of the Tri-State highway, skirting, as the maps show, the southwestern part of the area, and other nearby expressways has revolutionized shipments of goods and raw materials. Many industries have shifted to complete dependence on trucking, while some of the heavier industries continue to rely on the railroads. The main reason for the increase of truck transport has been the speed and convenience of the modern expressway, along with the increased care in handling which has significantly reduced breakage in shipment. As one described it: "To ship by rail, we would need a warehouse at the customer's end of the line to separate the different orders for final shipment by truck to the various customers." Thus, it is apparent that trucks are much more in demand than railroads as a means of convenient and economical, direct shipment. Modern highways have also increased the range of travel of the company salesmen and the radius of the market.

A look at the map may also well raise the question, "What about the Calumet-Sag Canal for cheap transportation, especially for the bulkier and heavier commodities?" As of the moment, manufacturers in Blue Island proper generally do not envision much use of the canal in the near future. Even Clark Oil and Refining Corporation, employing about 300 men and doubling its capacity within the last three years to 35,000 barrels of crude oil a day, is abandoning an increasing amount of its barge and rail traffic in crude oil for the more economical pipelines delivery directly from the oil fields of Texas and Oklahoma. A more diagnostic-prognostic appraisal of the canal traffic situation will be given under the concluding topic of this paper.

Sources of Raw Materials Primarily Regional

Of all the factors of the manufactural pattern in the area, the site of manufactured steel products in relation to that of raw steel is a primary one. Keeping in mind that the Lake Michigan area leads the United States in raw steel production, with mills at South Chicago, Indiana Harbor, Gary, and most recently, at Burns Ditch (sites 1-2, 3, 4, 5, respectively, on insert map), it is readily understandable that the Calumet-Chicago area dominates in source of supply of raw materials for the Blue Island area.

The expression commonly used by the respondent to the questionnaire is, therefore, either "Chicago" (meaning the wider, larger Lake Michigan Area) or the "Middle West," or sometimes the word "local" is used, when, as one reports, 90 per cent of raw materials is derived from local regions. Of the various sources of steel, Gary is mentioned most commonly, although South Chicago and Indiana Harbor are also specified. Several plants reach out for raw steel all the way to Pittsburgh, while others even go so far afield as Western Europe for particular types of structural steel.

Manufactured products other than steel involve both local and distant geographic sources. Thus, in the manufacture of metal castings, sand is shipped in from Ottawa, Illinois, and Beloit, Wisconsin; cement from Buffington, Dixon, LaSalle; and stone from Thornton, Illinois—all local-regional sources; fiber glass from Newark, Ohio; paper from Wisconsin and from southern paper mills; crude oil from Texas and Oklahoma; and zinc from Joplin, Missouri. Food processing, featuring the canning of tomatoes and pickles, is centered upon products from the immediate area as well as from Wisconsin, Michigan, and Colorado.

Value Added by Manufacturing and Geographic Distribution of Markets

It is recognized by geographers that value added by manufacturing is a criterion of increasing importance in appraising the significance of manufacturing in any area. But it is also one of the more difficult set of data to secure from plant to plant. Though a number reported specifically dollar value added, which ranged from $75,000 a year to as high as $20,000,000, the more significant entries seemed to have been based on percentage of one type or another, depending in large measure upon the type of product manufactured. Such percentages range from as low as 50 to over 200. Examples: electrical and mechanical

components, 50 per cent; likewise railroad refrigerator car parts, street lights, and so forth where the conversion cost adds 50 per cent; fiber drum barrels, 60 per cent of sale price; structural steel fabricators, 75-100 per cent; high carbon steel wire, 200 per cent; rods, 229 per cent.

The greatest diversity of products manufactured in the Blue Island area, conjoined with all the more or less optimal conditions of manufacturing, insures a great diversity of markets as well as an expansive geographic distribution of manufactured products. Over one-fifth of the interviewees expressed the importance of markets—both near and far. Thus the recognition of the areal proximity to metropolitan Chicago; "good retail outlet area," "economical marketing." The economy and adequacy of transportation are, however, reflected in other ways than proximate facilities. So efficient is the production of certain commodities in the Blue Island area that manufacturers have been able to utilize the excellent transportation system in capturing markets in the backyards of competitors as much as a thousand miles away, as, for instance, on the Eastern Atlantic Seaboard. In such cases, all, or part of the freight rates, is assumed by the manufacturer. In some cases negotiation for special freight rates may also play a role in capturing the more distant markets.

Depending partly on the type of manufactured goods, the markets areally classify as local, single or multiple states, nationwide, and exports abroad. Thus, concrete pipes and conduits, and brick are representative of primarily local-regional market distribution. As reported by one of the establishments of the former type of industry, sales are primarily in Cook County ($600,000,000), Lake County, Illinois ($100,000), and Lake County, Indiana ($100,000).

Single and multiple state markets: Report on such distribution of products range areally all the way from one to ten states. Such are primarily concerned with the marketing of various types of steel products (e. g., steel drop forgings are shipped to Illinois, Indiana, Michigan, Wisconsin; cut steel and sheet metal to California; and steel kitchen cabinets to Texas).

Regional: wire products to the Midwest; electric transformers to the East Coast (25 per cent), West Coast (10 per cent), Mid-America (60 per cent).

Nationwide: industrial soaps, railroad refrigerator car parts, street lights, identification poles, trucked refrigerator units, steel doors, signs and signal warning devices "to all 50 states."

Exports: the sign and signal products just mentioned, to Canada; cut steel and sheet metal to Australia, Greece, India; terminal points, and switches for underground electric cables, world-wide, including Thailand, South America, and Africa; dental and surgical instruments to Sweden, Denmark, Australia, South Africa, and Latin American countries.

Labor Accessibility

Adequacy of labor supply and its residential proximity are primary factors in the efficiency and economy of plant operation in the Blue Island area. The number employed roughly fall into three categories:

1) approximately five plans each employing 1-10, 11-20, 21-30; 2) approximately two plants each employing 81-90; 101-125; 126-150; 151-200; 201-250; 251-300; 301-400; 3) one plant, 775 (375 men, 400 women). In every case, the automobile is predominantly the mode of transportation of the employees; supplemental busses (South Suburban Safety Lines) are mentioned only sixteen times, and the train only twice. This vehicular transportation pattern suggests the geographic proximity of labor residences, locationally identified by such designations as: Blue Island; Harvey; South Chicago; Chicago Heights, north to 115th Street; southern suburbs; Cook County, Illinois; Lake County, Indiana; 10-15 miles radius; Metropolitan Chicago. But the extraordinary predominance of auto transportation also suggests a parking problem, particularly for the plants located within the city proper, another reason for the shift of industry to the periphery of the corporate limits and beyond. So far, housing developments in the labor source areas seem to have kept pace pretty well with the increasing industrialization of the region, and no industrial housing projects as such were noted.

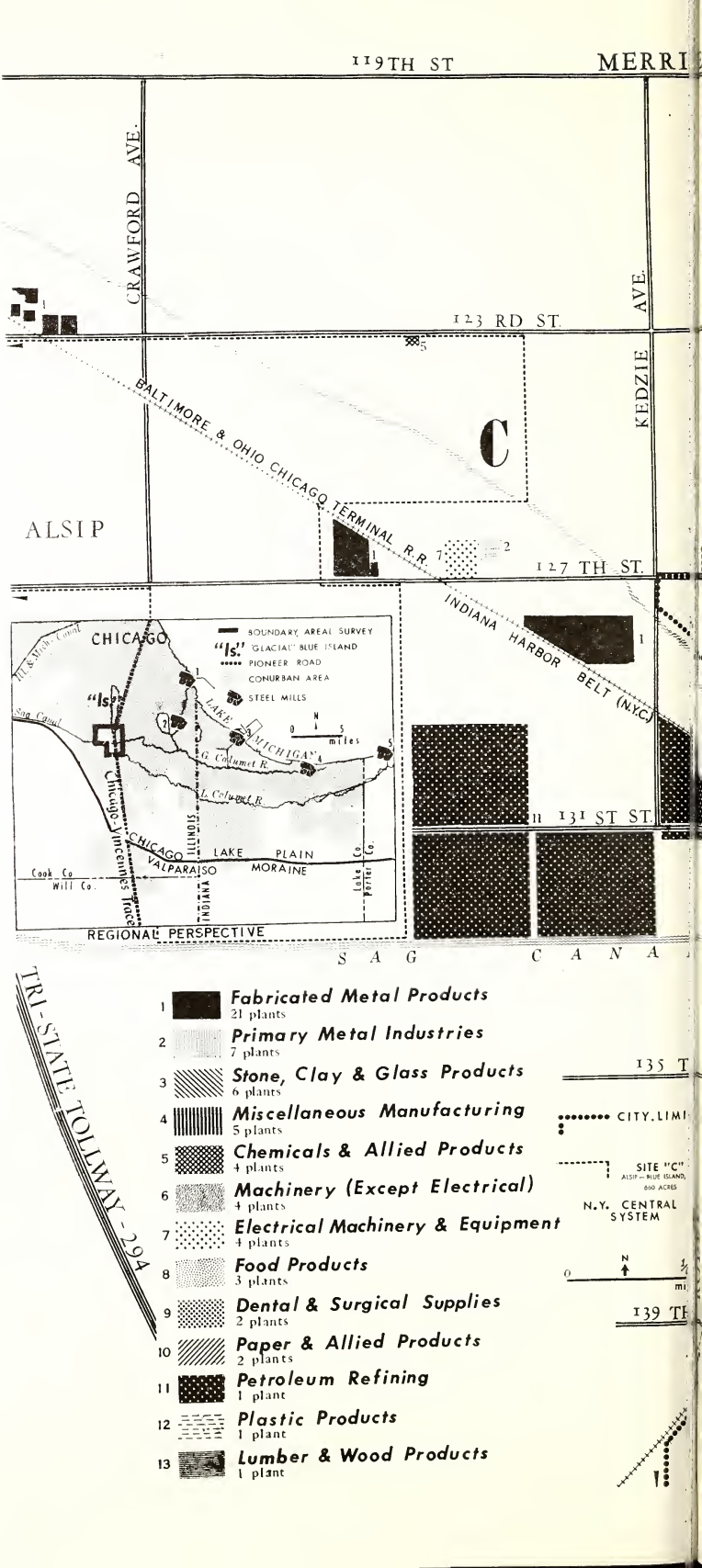
Industrial Utilities

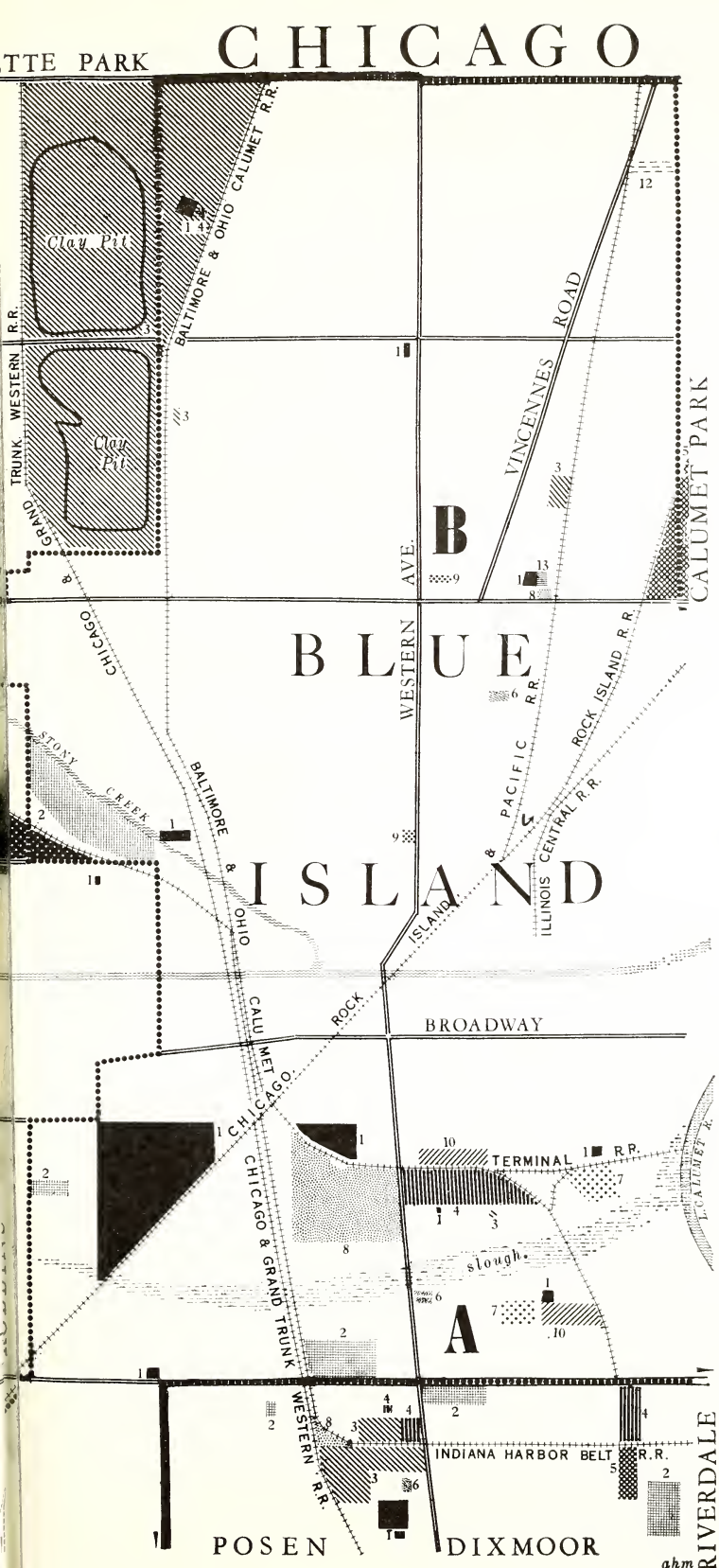
Since a 1915 agreement with the city of Chicago, Blue Island has used Lake Michigan water piped through Chicago lines to the city limits. About 80 per cent of the replying industries have stated that both quantity and quality are from good to excellent, although at times during summer droughts, the quantity does get rather low. The Clark Oil and Refining Company uses the water of the Calumet-Sag Channel for cooling purposes. Electricity is supplied by the Public Service Company of Northern Illinois and gas by the Northern Illinois Gas Company. Both power supplies have been given an excellent rating in reliability and quality of their service. Coal, oil, and propane tank gas were listed as possible substitutes, but the industries seem rather reluctant to have to depend on these sources, probably because of the increased cost and inconvenience that a switch would incur. Sewage is adequately handled by the Chicago Sanitary District, with the exception of a few smaller plants, which use a septic tank system, and one reporting the use of the Little Calumet River.

Future Perspective

Field reconnaissance of the Blue Island incorporated area gives one the impression that sizeable sites for new industries, especially "heavy industries," or for the expansion of already established industries, are rare. This situation is likewise confirmed by the questionnaire and interview respondents, as well as by information from the office of the Chamber of Commerce. As pointed out by its president: Blue Island is 95 per cent built up, and is hemmed in on all sides, except in the Clark Oil area. Remaining sites as are available within the incorporate limits are small tracts generally unsuited for large industrial development, or are zoned in areas restricted to "light industries," which zoning permits in the business district, with a set back of 125 feet from the street, or as second or third floor occupants (8).

As has been indicated earlier in this report, inadequacy of single space sites, or of large integrated units of space, were two of the


119TH ST
MERRI
CRAWFORD AVE.
123 RD ST.
KEDZIE AVE.
BALTIMORE & OHIO CHICAGO TERMINAL R.R.
C
ALSIP
127 TH ST.
INDIANA HARBOR BELT (N.Y.C.)
131 ST ST.
CHICAGO
BOUNDARY, AREAL SURVEY
"Is." "GLACIAL" BLUE ISLAND
PIONEER ROAD
CONURBAN AREA
STEEL MILLS
"Is."
Sag Canal
LAKE MICHIGAN
0 5 miles
G. Calumet R.
L. Calumet R.
Chicago Limestones Tributary
ILLINOIS
INDIANA
CHICAGO LAKE PLAIN
VALPARAISO MORAINE
Cook Co
Will Co.
Lake Co
Porter Co
REGIONAL PERSPECTIVE
S A G
C A N A
TRI-STATE TOLLWAY - 294
1 Fabricated Metal Products
21 plants
2 Primary Metal Industries
7 plants
3 Stone, Clay & Glass Products
6 plants
4 Miscellaneous Manufacturing
5 plants
5 Chemicals & Allied Products
4 plants
6 Machinery (Except Electrical)
4 plants
7 Electrical Machinery & Equipment
4 plants
8 Food Products
3 plants
9 Dental & Surgical Supplies
2 plants
10 Paper & Allied Products
2 plants
11 Petroleum Refining
1 plant
12 Plastic Products
1 plant
13 Lumber & Wood Products
1 plant
135 T
CITY LIMI
SITE "C"
ALSIP — BLUE ISLAND,
660 ACRES
N.Y. CENTRAL SYSTEM
N
0
mi
139 TH


TTE PARK
CHICAGO
BALTIMORE & OHIO CALUMET R.R.
Clay Pit
Clay Pit
GRAND TRUNK WESTERN R.R.
VINCENNES ROAD
B
AVE.
CALUMET PARK
BLUE
ISLAND
WESTERN
CHICAGO
STONY CREEK
BALTIMORE & OHIO
PACIFIC R.R.
ROCK ISLAND R.R.
ILLINOIS CENTRAL R.R.
ISLAND
ROCK
BROADWAY
CALUMET
CHICAGO
TERMINAL R.R.
L. CALUMET R.
slough
A
CHICAGO & GRAND TRUNK
WESTERN R.R.
INDIANA HARBOR BELT R.R.
POSEN
DIXMOOR
RIVERDALE
ahm

major reasons why many of the industries once located in Chicago moved out into Blue Island. But now the city itself, like Chicago, has become industrially saturated, and so industries entering the Greater Blue Island region are being established in the neighboring areas to the west, and to the south.

While interviewees reported for the most part no particular problems of their own as to adequacy of space, several did make qualifying comments regarding the matter on a community basis: "Ineffective promotion of available industrial sites," "good suitable ground is being utilized in other ways"; "plant investment requires large land sites for long-term operations"; "much of the land has to be reclaimed from swamp or lowlands." One observer emphasized, "need planning commission badly."

It is not clear how effective planning can be in a community "already built up" and when the industrialists were confronted with the question on the future adequacy of zoning and geographic planning, there was general indication of satisfaction with the zoning as it now exists, limited interest was expressed in the need of future planning. Several did indicate the need of "new zoning requirements." It would appear, then, that systematic geographic planning would be primarily restricted to commercial and residential functions. As to any consideration of "urban renewal," it appears that sentiment is in favor of private enterprise as compared with governmentally controlled developments.

Whether a Blue Island planning commission eventually develops or not—there is presently some belated civic agitation for it—major industrial enterprises seeking location in the West Calumet will look elsewhere for "industrial park" sites (beyond the corporate limits of Blue Island). One such development is promoted by the New York Central System—two sites south of Lake Calumet; one to the northwest, near Bedford Park (vicinity, Illinois and Michigan Canal); and two in the Alsip area, one of which, so called Alsip Industrial Site "C" is projected for the most part on the map. The total site approximates 660 acres. A brochure geographically identifies the topographic and transportation features thus: Situated 15 miles south of the Chicago's Loop . . . the site is 7 miles west of the Lake Calumet Harbor and immediately north of the Calumet-Sag Channel . . . is level and at grade with the Indiana Harbor Belt Railroad and surrounding streets. . . . Test borings taken in the general area have been favorable for foundations. The site is served by the Indiana Harbor Belt Railroad, a part of the New York Central System. . . . It provides fast and frequent service to and from all trunk line railroads operating in the Chicago area and over 500 industries in the Chicago Switching District. The new Tri-State Tollway (passes) through the site with an interchange located at its intersection with U. S. Route No. 50 (Cicero Avenue) . . . , a major north-south four-lane highway connecting with all east-west roads in the vicinity. Chicago's Midway Airport is conveniently located 8 miles north of the site at 63rd Street and Cicero Avenue. The Cal-Sag Channel borders the site on the south and is a vital link in the National Inland Waterway System. Dock facilities may

be constructed on the north bank of the channel, thereby allowing water transportation to this area" (9).

What local industrial effects are anticipated as a consequence of expanding port developments on Lake Calumet and along Lake Michigan, including the newly proposed site of Burns Ditch; the deepening and widening of the Sag Channel to the West; and the waterway extension facility to the East by way of the St. Lawrence Seaway?

A surprisingly large number of respondents to questions such as these (some 16 of them) indicated they did not see any effect of new port developments, except possibly in connection with Lake Calumet (e. g., "foreign steel now received through Lake Calumet"; "Calumet Harbor is used"). The presumption here is that this harbor will play a continuing role in such traffic. But harbors with wider berths and deeper draught facilities are associated also with increasing competitive imports of foreign steel products. One observation, for example: "All (improvements) would make available less costly commodities from Europe, adding to unemployment problems."

It is postulated that the deepening and widening of the Sag Channel would also not be of added appreciable service to the industries in Blue Island proper, with their already established truck-train-warehouse patterns. Moreover, as pointed out by a local engineer, dockage space in Blue Island itself is practically non-existent, and private industries have virtually bought all the land along the canal to the west. This latter observation presages an expected boost to the general economy of the West Calumet as new incoming industrialists envisage reduction of transportation costs by water.

Since the completion of the St. Lawrence Seaway, there have been some new imports of European steel, with prospects of further increase of such. Apprehensive of this, a manufacturer seeks restrictive controls on imported fabricated steel to save his market. Trade, being what it is, geographically operative on a "two-way thoroughfare," the effect of a deep waterway all the way from the Gulf of St. Lawrence to the Gulf of Mexico upon each of the area through which it passes, including the Blue Island area, will no doubt be as varied as the different types of classifications of industries here presented on the map, a detailed manufactural-market complex too involved to engage us here.

Whatever resolutions of the potential future markets may be for the Blue Island area manufacturer, the general concensus of the industrialists contacted expresses confidence in the continuing geographic advantages: in the words of one of them, "central location, good roads, ample water and power supplies, and ample labor force."

Literature Cited

1. Leverett, Frank, 1897. The Pleistocene Features and Deposits of the Chicago Area, The Chicago Academy of Sciences, Bulletin No. II., p. 46.
2. Meyer, Alfred H. 1954. Circulation and Settlement Patterns of the Calumet Region of Northwest Indiana and Northeast Illinois, Annals of the Association of American Geographers, XLIV: 265.
3. The Blue Island Story, An Historical Review, sponsored by the Lions Club of Blue Island. 1962, p. 8.

4. **Op. cit.**, p. 12.
5. All Roads Lead to Blue Island, 1962. Blue Island Chamber of Commerce, p. 1.
6. Calumet-Sag Navigation Project, 1959. Corps of Engineers, U. S. Army Engineer District, Chicago.
7. Standard Industrial Classification Manual, 1957. Executive Office of the President, Bureau of the Budget. Office of Statistical Standards.
8. Lloyd C. Holmlin, President, Blue Island Chamber of Commerce, Interview.
9. The Greater Chicago, Illinois, Area Industrial Sites, 1957. New York Central System.

A Comparison of Ten, Twenty-five and Fifty Year Climatic Records

J. C. Hook and A. J. Cantin, Indiana State University

In many problems in Climatology it is necessary to use data from stations distributed over wide area. Usually it is desirable to use as many stations as possible. Doubts constantly arise, however, because the records from these widespread stations are seldom of uniform length and one is constantly questioning the propriety of comparing records of say 50 years with those of shorter periods. It is the purpose of this paper to investigate the significance of the length of the climatic record on certain selected data; the absolute high temperature and the absolute low temperature for the months of January and July recorded at eighty-nine stations in the United States. An attempt was made to determine how accurately records of 25 years and records of 10 years in length reflect the conditions recorded during 50 years. Data were obtained from the Climatic Summary of the United States (Bulletin W) U. S. Department of Agriculture, Weather Bureau. The stations were chosen because they had records of more than 50 years.

In selecting the samples, the 50 years and the 25 years immediately preceding 1930 (the most recent date in bulletin W) were chosen. The 10 year periods were randomly selected from the 50 year data.

The records for 25 years are essentially the same as the 50 year records. For the January high temperature, the mean is 70 for the 50 year period and 69 for the 25 year period. The difference in the means of the two periods for both the high and low July temperatures were also one degree (50 year July high 104; 25 year July high 103; 50 year July low 49; 25 year July low 50.) The difference in the January low temperatures was a little greater, —13° for the 50 year period, —9° for the 25 year period. Tests of the differences between the means and the difference between the variance^2 in the two series show that there is no statistically significant difference between the two series.

The differences between the 50 year records and the ten year records are shown in Table 1.

Once again the greatest departure from the 50 year record occurs in the ten year record for maximum January low temperature and this departure amounts to five degrees.

A comparison of all the values from both records indicates a mean deviation of 2 degrees and a standard error of estimate of 4 degrees. This means that if the values obtained from the ten year record are used to predict the values for the 50 year period they would be in error by 4 degrees or less in 66 per cent of the cases.

The greatest departure for an individual station occurs in the January high temperature of Oswego, New York. The ten year record indicates a maximum high temperature of 40 degrees, the fifty year record, 69 degrees; a difference of 29 degrees. There was one other difference greater than 20 degrees. This occurred in the data for Marquette, Michigan, when the 10 year January high temperature was

24 degrees less than that recorded in the 50 year period. Two stations, Phoenix and Shreveport, had differences of 19 degrees and two others, Helena and LaCrosse, had differences of 18 degrees between the 10 year and 50 year records.

TABLE 1
Difference between 50 year and 10 year records

	MEAN (°F)		STANDARD DEVIATION (°F)	
	50 year	10 year	50 year	10 year
Absolute Max. January	70	67	11	9
Absolute Min. January	—13	—8	2	2
Absolute Max. July	104	101	5	5
Absolute Min. July	49	51	8	8
All values	53	52	44	41

These departures seem to be random. They are scattered all over the country, which rules out any pattern of a regional variation. It was thought that a station with a great range in the temperatures might show a greater departure than those with a small range. Five of the six stations having differences of 18 degrees or more between the 50 year and 10 year records had these differences occur in the January data. The mean range of the January absolute temperature is 83 degrees, standard deviation 13 degrees for the 50 year record. Only two of the five (Helena range 105 degrees, LaCrosse range 99 degrees) had a range in their absolute January temperature greater than one standard deviation from the mean. The mean range in the July temperature was 55 degrees, standard deviation 9 degrees. Phoenix, which had a difference of 19 degrees between the 10 and 50 year records in the absolute low July temperature, had a July range in temperature of 72 degrees.

The time interval between the dates on which the absolute high and low temperature were recorded was also investigated. In the 50 year records, this interval averaged 17 years for the January data and 16 years for the July data. Portland, Oregon, recorded its absolute high (62°) and absolute low temperature (—2°) the same year (1884) and Boise, Idaho, recorded its absolute July high (111°) and absolute July low (40°) in 1898. The interval between the absolute high and low temperature for both January and July averaged 8 years in the 25 year sample and five stations had either the January or the July maximum and minimum occur in the same year. For the ten year record, the average time interval between the date in which the high for the month and the low for the same month was recorded was 4 years. Fifteen stations recorded the ten year maximum and minimum for either January or July the same year. There does not seem to be any relationship, however, between these time intervals and the differences between the fifty year and ten year record.

In conclution, this study has shown that in regard to the absolute maximum and absolute minimum temperatures in the United States, a 25 year record is essentially the same as a 50 year record and that a

ten year record will be within 4 degrees of the 50 year record 66% of the time. Differences of 18° or more between the 10 and 50 year records are small in number and seem to be randomly distributed.

Literature Cited

1. Scarborough, J. B. and R. W. Wagner. 1948. Fundamentals of Statistics, New York, Ginn and Co. P. 107.
2. Walher, H. and J. Lev. 1953. Statistical Inference, New York, Holt, Rinehart and Winston, P. 192.

Noncongressional Land-Survey Divisions in Indiana[1]

ALLAN F. SCHNEIDER, Indiana Geological Survey

Introduction

The system of land subdivision familiar to most Indiana residents was established on May 20, 1785, by an act of the Continental Congress and is therefore generally known as the congressional system. It is also called the rectangular system. Briefly, the Ordinance of 1785 and subsequent legislative acts pertaining to public-land surveys provided for the establishment of the township, a geographic unit approximately 6 miles square. Each township is subdivided into 36 units of 640 acres each called sections, each of which is approximately 1 mile square and is in turn subdivided first into quarter-section lots and then into 16 smaller rectangles of 40 acres each.

Under the provisions of the Ordinance of 1785, only part of what is now the State of Ohio was ordered to be surveyed. Legislation providing for the subdivision of public lands in Indiana according to the rectangular system was not enacted until several years later. During the interim other land surveys of a more specific nature were ordered and completed; these did not follow the congressional plan, nor did, of course, any pre-1785 surveys, many of which followed an old French system. Furthermore, actual surveys implementing the congressional land acts could not be completed for a number of years, during which time additional private land claims were established. When the congressional surveys were finally made, it was necessary to honor the boundaries of these existing claims. There are, therefore, in Indiana various types of legal land tracts that are not laid out and described in accord with the congressional system.

Nature and Origin of Noncongressional Units

Noncongressional land-survey divisions exist in three parts of the State (fig. 1). These areas are (a) in southeastern Indiana at and north of Jeffersonville, (b) in southwestern Indiana around Vincennes, and (c) in northern Indiana, where a large number of noncongressional land units are distributed throughout an area of nearly 20 counties.

In southeastern Indiana the congressional system of land division is not used in an area of about 250 square miles known as Clark's Grant, which is located north of the falls of the Ohio River at Jeffersonville and New Albany (fig. 1). Most of this land is in Clark County, and the remainder is in southern Scott County and eastern Floyd County. The grant consists of 298 individual units that are simply called lots or surveys.

Clark's Grant, which is also called the Illinois Grant, was conveyed to Gen. George Rogers Clark and the members of his regiment as a reward for capturing British posts in the Illinois country during the Revolutionary War. The grant was initiated through a resolution

[1]Published with permission of the State Geologist, Indiana Department of Conservation, Geological Survey.

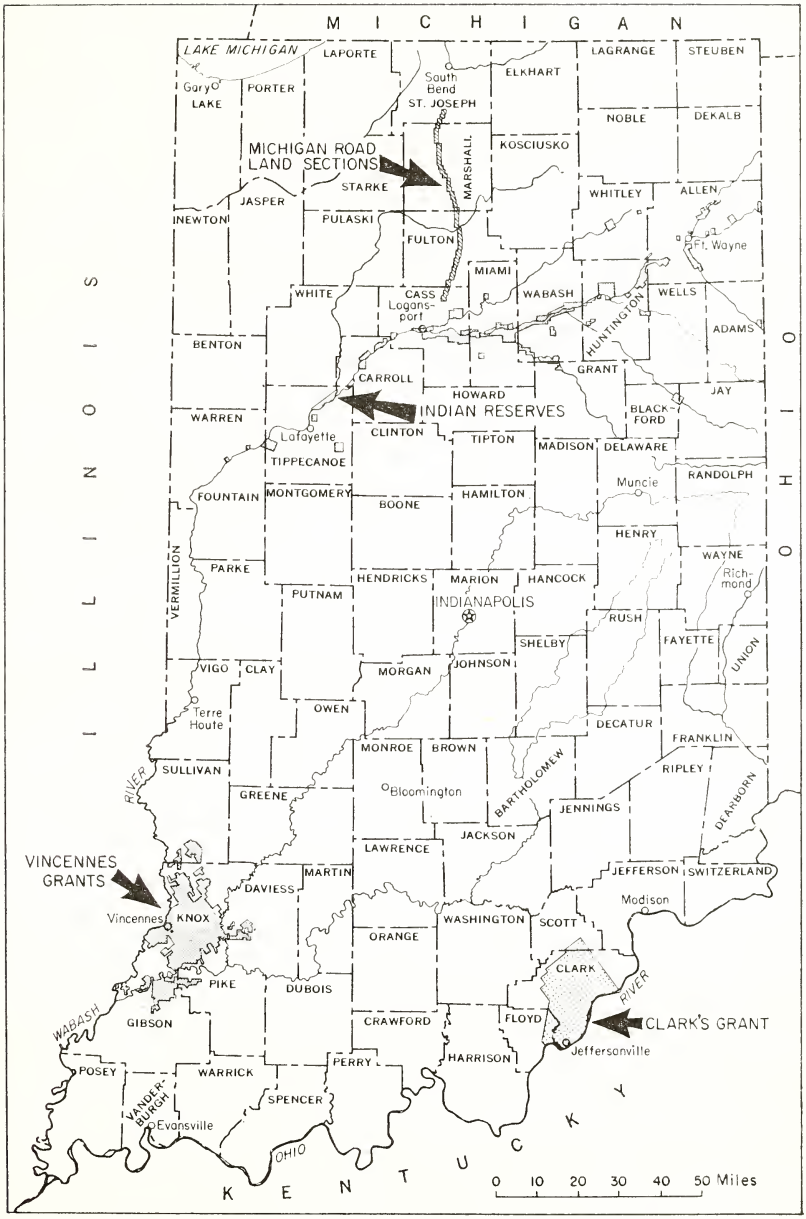


Figure 1. Map of Indiana showing areas of noncongressional land-survey divisions.

adopted by the General Assembly of Virginia in 1781 and through more definitive legislation passed by the Virginia Legislature in 1783. According to this law, a 1,000-acre tract was to be reserved for a town, to be called Clarksville, and the remaining 149,000 acres of the grant was to be surveyed into lots that were not to exceed 500 acres each; with few exceptions, however, the lots are generally larger. The survey and official plat map of Clark's Grant appear to have been completed in 1785, although a patent for the land was not signed by Governor Randolph until December 14, 1786. When the Illinois country was ceded to the United States in 1783, Virginia retained her sovereignty with regard to the right of land legislation in the Illinois Grant, and thus the area never became subject to Federal laws governing the survey of public lands (3).

The second area of the State where noncongressional land-survey units exist is in the Vincennes region in southwestern Indiana (figs. 1 and 2). Early land claims in this area had been established in several different ways, and in order to make certain adjustments in these claims and to provide for additional grants to settlers at Vincennes and elsewhere in the Illinois country, Congress passed a series of resolutions and laws (4). The principal legislation was enacted on March 3, 1791. This act effectively created the several types of noncongressional land-survey divisions that are found in Knox, Gibson, Pike, Daviess, and Sullivan Counties. At least five distinct types of units are recognized in this area: donations or donation lots, common lots, militia donations, locations, and surveys (4, 5). The exact status of a few other land claims not falling within one of these categories is unknown.

Donations or donation lots (fig. 2) are so named because they were outright gifts of the Federal Government, a lot of 400 acres being donated to the head of each family who in 1783 resided at Vincennes or nearby in the Illinois country. There are 246 donation lots covering 98,400 acres; these lie mainly in central Knox County, but extend across the White River into westernmost Daviess County. In addition to the donations, the residents of Vincennes were given 5,400 acres of land to be used as a common. When this area was later subdivided, the individual lots quite naturally became identified as common lots; they are grouped into Divisions A, B, and C (fig. 2), the divisions containing individual lots of three different sizes. The militia donations were given to persons who had served in the militia at Vincennes but who did not receive a regular donation. There are 128 of these 100-acre lots in northeastern Gibson County (4, 5).

When the donations and militia donations were established, many individuals were forced to forfeit earlier land claims. Other legislation permitted these persons to locate elsewhere, however, and to make new claims, which are consequently called locations (fig. 2). These lots are irregular in both size and shape; about 310 of them are distributed in Knox, Gibson, Pike, Daviess, and Sullivan Counties and on the west side of the Wabash River in Illinois.

In general, persons outside the donation tracts were permitted to retain land that had been acquired at some earlier time. The 1791 law

provided for the survey of these claims; thus they are called surveys (fig. 2). Several hundred of these units are present in various parts of Knox, Pike, Sullivan, and Gibson Counties. Many of these earlier claims were grants made by French and British military authorities or by a civil and criminal court at Vincennes; consequently they were surveyed by different methods. The long narrow lots southwest of Vincennes (fig. 2), for example, were laid out according to a French system.

Two kinds of noncongressional land-survey units exist in northern Indiana: Michigan Road Land sections and Indian reserves. Both have their origin in treaties between the United States and various Indian tribes that once occupied the area.

The Michigan Road Land sections consist of 45 sections of land, each approximately 1 mile square, that extend from southern St. Joseph County southward through Marshall and Fulton Counties into northeastern Cass County, where they terminate about 9 miles northeast of Logansport (fig. 1). This strip of land was ceded to the United States by the Pottawattomie Indians and was then relinquished to the State of Indiana. The State in turn offered the land for sale, and the proceeds of the sales were used for the construction of the Michigan Road, which ran from Michigan City (La Porte County) to Madison (Jefferson County) via South Bend, Logansport, and Indianapolis (1). The survey of most, if not all, of the Michigan Road strip in northern Indiana was completed in 1828, or about 5 years before congressional surveys established the rectangular system of land division in this area. When the latter surveys were made in the 1830s, congressional section lines were not carried through the Michigan Road Land strip.

Indian reserves are, as the term implies, parcels of land that were reserved for the Indians. These reserves are located in about 15 counties, stretching across the State from Warren County on the west to Allen and Jay Counties on the east (fig. 1). Their distribution is closely related to the drainage system in this part of the State, the reserves being situated mainly along the Wabash River and its upstream tributaries. The greatest concentration is in a belt that extends from Logansport in Cass County upstream through Miami, Wabash, and Huntington Counties to the vicinity of Fort Wayne (fig. 1). The units are of all sizes and shapes, but in general the boundaries are straight except along rivers.

Virtually all the reserves are areas that were never ceded to the United States in any of the several treaties by which the United States formally acquired land from the Indians in this part of the State. Most of these treaties were signed in the period between 1818 and 1840, principally between the United States and the Miami and Pottawattomie tribes, but treaties with other tribes were also involved (1, 2). When these pacts were negotiated, parcels of land were retained by individual Indians or by relatively small groups of Indians. Many of the reserves are identified, therefore, by the name of a chief or other individual; others are identified by a name and a number, and a few by a number only.

It appears that, unlike the Michigan Road Land sections, many of the reserves were not surveyed until congressional surveys of these northern Indiana counties were made. Because lands in which Indian titles had not been extinguished were considered to be in the category of private land claims, the reserves were not subject to subdivision according to the rectangular system. Approximately 125 reserves are recognized in northern Indiana.

Problems and Solutions

Several problems inevitably arise because of the existence of noncongressional land-survey divisions in a State that is very largely surveyed according to the congressional system. The most obvious is confusion and consequent lack of uniformity in describing locations within the noncongressional units. Probably the most common solution to this problem is the projection of the rectangular grid into areas where it has not been established by actual land surveys. Although some method by which location descriptions can be related to the congressional system seems desirable, the projection of section lines across other land-survey units is clearly an improper practice.

After careful study of the problem, the Indiana Geological Survey has adopted a plan that seems to be both practical and in accord with good cartographic principles. In this system all noncongressional land-survey divisions—donations, surveys, reserves, etc.—are recognized as discrete units. No known noncongressional units are ignored or abandoned, as is essentially done when sections lines are extended into areas where section corners have not been established. The various units are, however, assigned to congressional townships and are accordingly described by the usual township and range designations.

A noncongressional survey unit that is physically within the boundaries of a congressional township obviously presents no problem in description. The location of survey 52 south of Vincennes (fig. 2), for example, can be described as T. 2 N., R. 10 W. It would be improper, however, to extend section lines through this survey; the location of a feature within the unit should be described with respect to the survey itself and not with reference to any of the four fractional sections involved.

A noncongressional survey unit that lies athwart one or more township boundaries (for example, location 7 in the southeast corner of figure 2) is not so easily described, unless some special provision is made for township and range designation. Again, it would be improper practice to make straight-line projections of congressional lines, in this case township and range lines, so as to place the unit in two, three, or even four different townships (as in the case of location 7). Therefore, the unit is treated as a whole and assigned to a single township.

The large area of some land tracts that contain many individual smaller units obviously cannot be kept intact, and it is necessary to run arbitrary township and range lines through these tracts. In so doing, however, the wholeness of individual units is retained, so that no individual unit is broken by a township boundary. The result is that arbitrary township boundaries are commonly irregular, as in the area

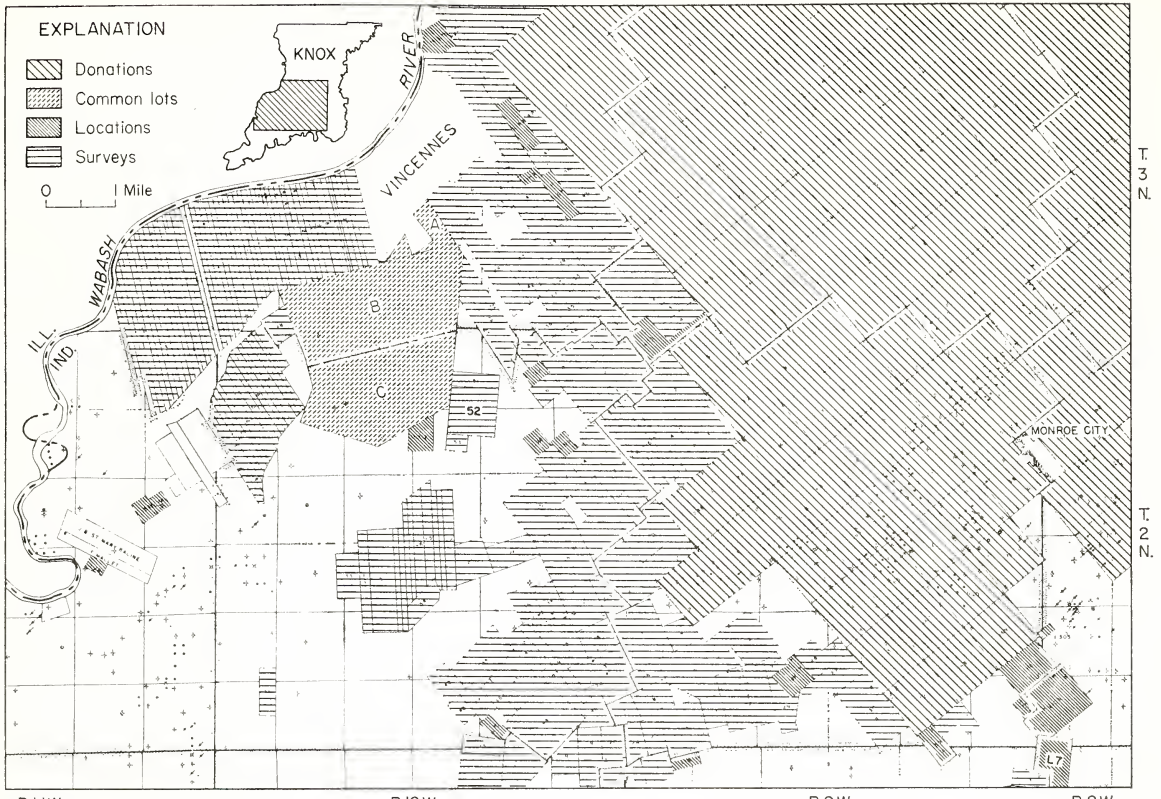


Figure 2. Map of part of Knox County, Indiana, showing noncongressional land-survey divisions and township boundaries in the Vincennes area. Modified from Indiana Geological Survey Petroleum Exploration Map No. 23.

south of Vincennes (fig. 2). Where the individual noncongressional units are relatively uniform in size and shape, the township boundary takes on a zigzig pattern, as in the donation area of Knox County (fig. 2). Irregular township boundaries are infinitely more desirable, however, than split-up units.

In summary, the discreteness of all noncongressional units is retained in our system, yet it is possible to give a general location that is more specific than county name alone. This practice is particularly useful in making and utilizing all types of files and indexes.

The assignment of noncongressional units to townships is not entirely arbitrary on our part; it is based wherever possible on original congressional survey sheets or other reliable sources. Studies of the original survey sheets commonly yield factual information that is not elsewhere available and also give insight into the intent or judgment of the surveyors on certain matters. In the Vincennes area, for example, the survey sheets show surveys to be numbered consecutively within each township, and there usually is no question regarding the assignment of a survey that lies athwart a township boundary.

The Indiana Geological Survey has completed the preparation of petroleum exploration maps for 86 of the 92 counties in the State. Noncongressional land-survey divisions are known to exist in about 25 of these counties. Our completed maps outline and identify these units, which are assigned to congressional townships by arbitrary boundaries generally drawn in conformity with the original land-survey sheets. We would, of course, appreciate learning about any errors on these maps, but, in addition, we invite criticism of our solution to the problem of noncongressional land-survey units. The adoption of a uniform system of handling noncongressional units would go a long way toward clarifying location descriptions in these 25 counties, as well as providing a useful method of cataloging data. Our method has proved to be highly satisfactory to us, and it is hoped that other groups and individuals might also find it useful.

Literature Cited

1. Anonymous. 1876. Illustrated historical atlas of the State of Indiana. Baskin, Forster & Co., Chicago. 462 p.
2. Dillon, J. 1859. A history of Indiana, from its earliest exploration by Europeans to the close of the territorial government in 1816. Bingham & Doughty, Indianapolis. 637 p.
3. English, W. H. 1896. Conquest of the country northwest of the River Ohio 1778-1783 and life of Gen. George Rogers Clark, 2. The Bowen-Merrill Company, Indianapolis.
4. Lux, Leonard. 1949. The Vincennes donation lands. Indiana Historical Society Publications. 15:419-497.
5. McCord, C. G. 1886. Ancient titles or land grants. *In* History of Knox and Daviess Counties, Indiana. The Goodspeed Publishing Co., Chicago, p. 94-99.

Strip Coal Mine Reclamation Problems in Indiana

LEE GUERNSEY, Indiana State University

Introduction

This is apparently a timely topic since public interest is focused on strip coal mine reclamation problems from many specific angles. The states of Indiana and Pennsylvania have enacted legislative amendments to their existing strip mine reclamation laws during their last legislative assemblies, and the first strip mine reclamation act became effective in Illinois on January 1, 1962. It has been stated that the 1963 amendments to the strip mine law of Pennsylvania are "the single, most controversial piece of legislation of the past decade." (1.)

On the national scene, the passage of the Economic Opportunity Act of 1964, commonly termed the anti-poverty bill, has highlighted the physical and economic effects of strip mining. Outside of the state and federal governments, even more basic questions have been raised in Harry Caudill's book, Night Comes to the Cumberlands, and Frank Harvey's book entitled, Nightmare County.

A few decades ago, when strip mining operations were small and affected only a limited area, the general public was but little concerned about the impacts of strip mining. As a consequence, little was done about reclaiming strip mined lands. It has only been during the last few decades, when numerous hazards to our public health and safety have resulted from extensive strip mining operations, that the general public has become very concerned about the need for more widespread and better reclamation practices. Today, strip coal mining is attracting more public attention than ever before.

Environmental Problems

Strip coal mining has created reclamation problems which are related to the interaction of such site conditions as texture, compaction, and acidity.

The texture of Indiana's strip mined lands vary considerably from one part of the state to another. Such differences in the composition of the spoil banks markedly affect drainage problems, soil aeration, and soil moisture. Spoil banks composed largely of sand, sandstone, and hard shales have the advantage of better drainage, but are normally more droughty than spoil banks composed of clay, limestone, and soft shale.

The compactness of Indiana's spoil banks vary from about 70 to 90 per cent as dense as the adjacent unmined materials. Those having the lowest density are commonly composed of sandstone or sandy shale. The most compact banks normally contain the greatest amounts of silt and clay and were graded when wet.

The acidity of Indiana's spoil banks is affected largely by the oxidation of pyrite and marcasite contained within the coal. The resulting sulphuric acid is highly reactive and combine readily with

the aluminum of the clays. The result is to release large amounts of soluble ions at rapid rates. The acidity influences the availability of soil nutrients by its effects on both the solubility of minerals absorbed by plant roots and on the occurrence and abundance of micro-organisms. If limestone or other basic materials are present in the rock, the acid is neutralized and the pH of the spoil banks is nearer to seven.

Pollution Problems

Water pollution, resulting from acid drainage and sedimentation, is a serious problem associated with strip mining. It is responsible for long distances of some Indiana streams that are devoid of fishlife or vegetation. Sedimentation results from the erosion of spoil banks, denuded hillsides, and access roads. Sediment in streams destroys fish habitat, erodes bridges and roadways, clogs culverts, and aids in undercutting stream banks. It shortens the life of the flood control and water storage projects of the Wabash River watershed. Both acid drainage and sediment contribute to increased treatment costs for such downstream consumers as cities, industries, and farmers.

Land problems go hand-in-hand with water problems. The land that is downslope or downstream from a strip coal mine may receive eroded material from the mined area. It may become devegetated. In some cases sediment and coal fires have choked stream valleys until the fields become swampy and were abandoned for agriculture uses. There is some evidence that choked stream beds and the bursting of sediment-built dams are responsible for increased flood damages. Forest development is often altered and wildlife habitat destroyed. Stagnant pools commonly develop in old strip pits.

Acid mine drainage is a difficult problem because its adverse effects are extremely persistent. A stream may require more than two years to restore after acid mine waters have flowed through it for only one hour (2). It should be apparent that keeping acid mine waters out of streams or of diluting them so as to be nontoxic is fundamental to the wise uses of Indiana's waterways.

Grading Problems

Since the topography of strip mined lands is primarily man-made, it is the public consensus of opinion that the first step in reclamation is to reduce the relief of the spoil banks by grading. Poor aeration, water penetration and moisture conditions are frequently mentioned, but seldom measured, factors of graded strip-mined lands. They are usually said to be due to compaction from the weight of grading machinery and from the weight of materials which were located above the newly formed surface before grading.

The amount of compaction varies with a number of factors, including the length of time between stripping and grading, the character of the bank materials, the weight and type of grading machinery used, the time required for the machinery to perform the grading, and the moisture content at the time of grading.

Grading of spoil banks can be accomplishd in the mining process and does not have to constitute a separate operation. A dragline

with a long boom can precede the stripping shovel, take up the top soil and dump it between the two preceding spoil banks. The ridges left by the stripping shovel are covered and the intervening valley partially filled with topsoil. The result is not a level terrain but a corrugated surface with ridges about one-half the height of the ridges and the depth of the valleys which would have otherwise been formed. This type of grading is currently being done by several strip coal operations in Indiana (3).

Legal Problems

When one studies the difficult problems of how to reclaim existing strip coal mine lands, he finds that our state law presently in force is inadequate to handle the range of problems presented by strip coal mining. The law does not recognize that conditions vary, hence that external costs vary within the state. Nor does it recognize that both reclamation costs and potential benefits depend critically upon location and upon terrain conditions. The many geographic differences between areas of stripping are usually ignored. Regulations are normally applied across-the-board.

Actually, the appropriate kind and degree of grading depends upon the terrain, without major remodeling of the entire surface. Grading should permit development, at a reasonable cost, of the widest variety and the economically most profitable types of highly specialized land use.

On the other hand, a useful feature of Indiana's law is its provision for substitution of land. Rather than reclaim land now being mined, an operator can elect to reclaim an equal number of acres of land not previously reclaimed. Although open to possible abuse, substitution does permit reclamation on strip mined lands which will return the greatest net benefits.

Revegetation Problems

Since newly created spoil banks are barren of vegetation, detailed planting plans should be known at the time of mining. The most important problems to consider are proper selection of plant species, planting methods, planting stock, and special measures for erosion control.

One of the planting problems is that revegetation of Indiana's strip mined lands has been dominantly that of tree plantings. Studies have shown that forestry is the most productive use for the largest percentage of Indiana's land after strip mining. Tree plantings are normally the least costly kind of reclamation. Trees normally hide the unsightly lands quickly, and often provide an attractive cover. But, to date, all the trees which have been planted on Indiana's strip mined lands are of limited marketable value. Nevertheless, it is probably more important to have tree plantings which will provide a cover and nurse crop to curtail the severe weathering and erosion than it is to have marketable timber products.

Thousands of acres of Indiana's older strip mined tree plantations are now reaching a stage of growth when more information is necessary in order to determine how to manage the forests properly. But, to date, there have been only a few detailed studies analyzing proper

management of strip mined tree plantations, and very little has actually been done about the proper management of forest plantings on strip mined lands.

Land Use Problems

With proper study and more intensive reclamation practices, without a doubt past, present, and future strip mined lands in Indiana could be developed into such uses as parks, tourist attractions, nature trails, outdoor education centers, and many other recreational facilities which are badly needed now in Indiana.

The use of Indiana's mine lakes for fishing, boating, swimming, water skiing, fish hatching, stock watering ponds, farm and community water supplies, and lake frontages for homes and cabins could be greatly increased. Indeed, the possibilities of utilizing Indiana's strip coal mine lands and lakes for highly specialized purposes is almost unlimited. We need these specialized uses of surface mined lands and lakes now.

More intensive and more specialized land uses could bring a much higher economic productivity per acre, and would also be more aesthetically appealing to all. There is little reason to doubt that Indiana's lands disturbed by strip coal mining could be used more wisely and more intensively than they are now.

Conclusions

Reclamation is an inseparable part of strip coal mining, It can not be markedly improved without improvement in mining techniques. Achieving improved mining techniques becomes primarily a matter of preplanning.

Complete and comprehensive preplanning must consider the previous and intended use of the strip mined lands and the surrounding area, topography, agricultural value of the overburden, available mining equipment, degree of grading, cost of reclamation, economy of the area, and legal requirements. The planning of future land use depends not only upon the geographical characteristics of the area, but also upon the wishes of the land owner, and the desires of the surrounding community.

A forward-looking coal mining company will begin with the determination of the future land use and then ascertain the best way to combine their coal production with this determined goal. They will determine the kind of equipment, the method of mining favoring reclamation, the grading to be done, and the revegetation of the spoil banks. If these steps are taken by Indiana coal producers, strip mine reclamation can be of higher quality, produce better results, and reduce public criticism of strip coal mining.

Literature Cited

1. Dixon, Daniel B. 1963. Report of the Mineral Law Section. Pennsylvania Bar Association Quarterly. **34**:457.
2. Brooks, David B. 1964. Strip Mine Reclamation and Economic Analysis. Resources for the Future. (mimeographed) p. 27.
3. Guernsey, Lee. 1958. Reclamation of the Strip Mined Lands in Vigo County, Indiana. Proceedings of the Indiana Academy of Science. **67**:215-224.

Economic Groundwater Problems Encountered in the Development of a Housing Area Near West Lafayette, Indiana

TERRY R. WEST and DAVID J. BARR, Purdue University

Introduction

Homewood Addition is a housing development located approximately 3.5 miles northwest of West Lafayette, Tippecanoe County Indiana in the NW ¼ of sec. 35 T 22 N., R 5 W. It lies in a dissected upland about 4 miles west of the Wabash River and 1.5 miles north of U.S. Highway 52 and the town of Klondike.

In 1958 the area was subdivided into individual lots one half acre or more in extent. In most cases the lots were sold directly to prospective home owners who contracted with their builders for home

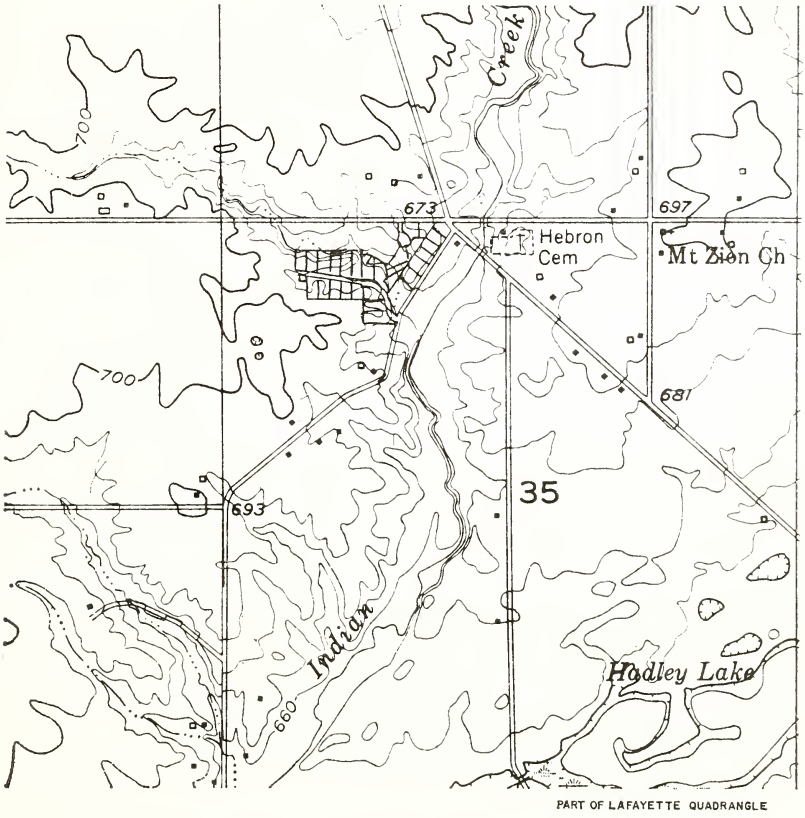
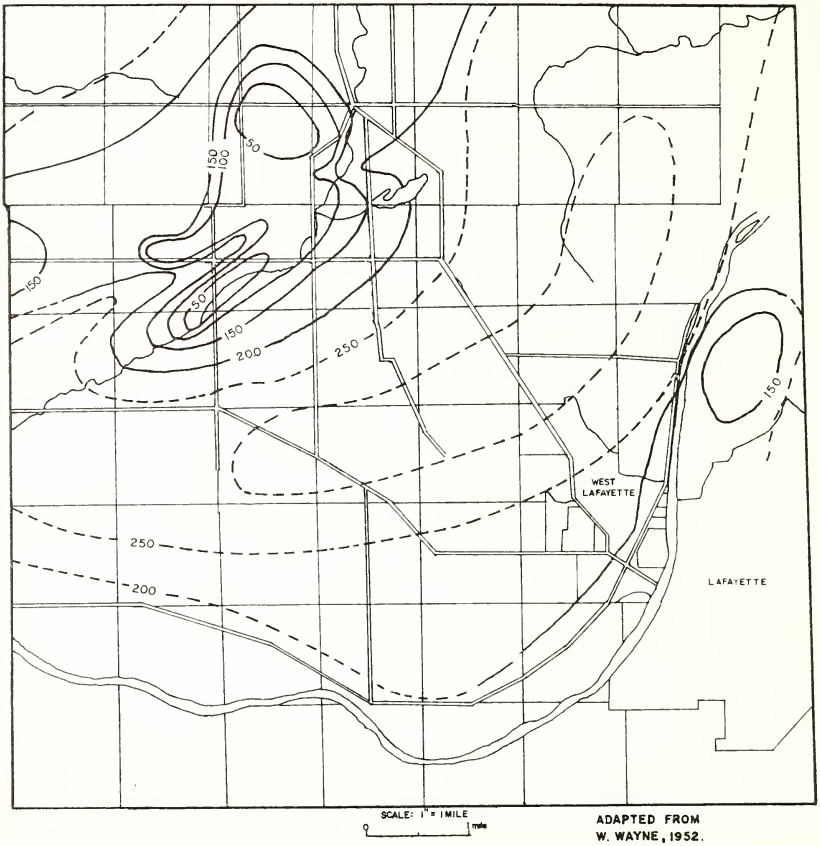


FIG. 1. TOPOGRAPHIC MAP OF THE HOMEWOOD AREA

FIG. 2. GLACIAL THICKNESS MAP OF A PORTION OF TIPPECANOE COUNTY, INDIANA.



construction. The final plots were sold in 1962 but construction, which was normally initiated some months after the land purchase, continued until 1964.

At present the housing development consists of twenty homes of contrasting design which are located on about fourteen acres. The topographic setting of the area is shown in Figure 1.

A water problem was encountered in the development of the Homewood Addition which is becoming increasingly common. The Homewood area is located several miles from the city limits of West Lafayette and is not serviced by its municipal water supply. Housing areas situated beyond available water systems in this manner must rely on groundwater acquifers for their source of water. Therefore, if any groundwater problems exist at the housing location grave difficulties can ensue.

In addition, water supplies for a modern home must be fairly substantial. Present day household appliance put a greater demand on water supplies than were experienced in the past as both an increase in water volume and the rate of water delivery are made necessary by their use. A groundwater supply which would have proved marginal or fairly adequate several decades ago would now be unable to satisfy the demands of modern living.

A disturbing aspect of the problem is that owners who build beyond municipal boundaries are commonly oblivious of groundwater conditions and possible water deficiencies. In many instances, groundwater supplies are either assumed to be available or the subsurface situation is investigated incompletely. It is all too common that the owners become aware of water difficulties only after their first dry well has been drilled and construction of their home is well underway.

Physiographic Setting of Homewood and Vicinity

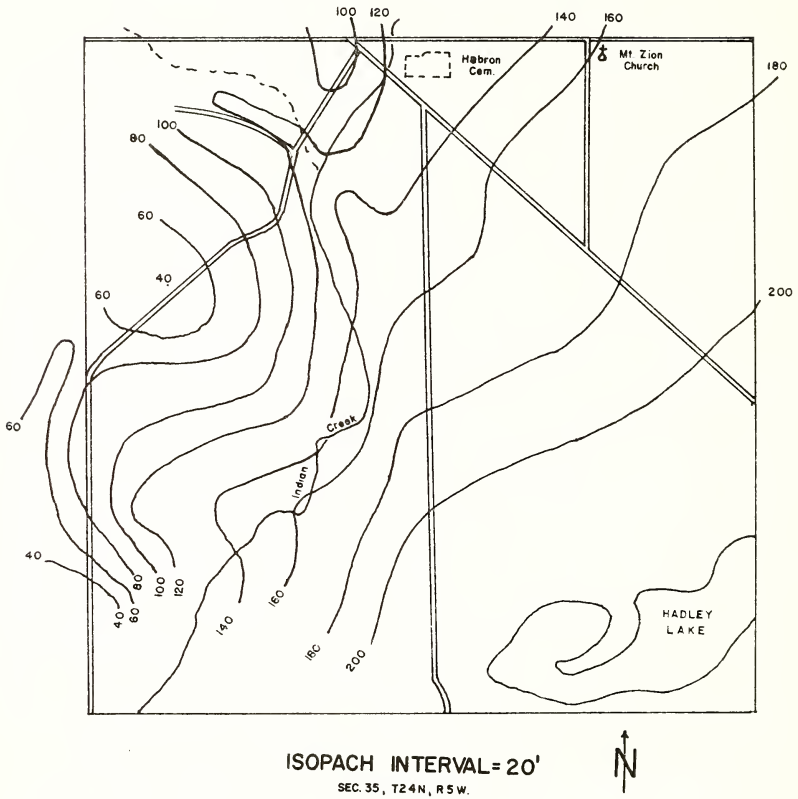
In section 35 of Tippecanoe County the surface is essentially flat to gently rolling. The maximum elevation in the area is 700+ feet whereas the maximum relief, created by dissection of the glacial drift, is on the order of 40 feet. Homewood Addition is situated on the sloping divide between the upland till plain and the lower outwash which forms a low swampy area elongated in a NE-SW direction. Hadley Lake and Blackbird Lake lie in this trough which may have originated as a sluiceway for glacial melt water. Schneider and others (2) have suggested that this elongated lowland is composed primarily of sand and gravel and that it may be an esker trough. Indian Creek enters this trough south of the Homewood area where it occupies the western margin of the depression and serves as the major drainage system for the till plain. In Figure 1, it can be observed that the creeks which drain the Homewood Addition and adjacent areas flow into this trough and are intercepted by Indian Creek. Although underlain by coarse sand and gravel, the depression is blanketed by bog deposits in many areas thus accounting for its swampy nature.

The till plain, which is less permeable than the lowland area, is being dissected by surface water along the margin of the Hadley trough. Northwest of the Homewood area, beyond the dissected margin, the till plain is essentially flat with little local relief.

Glacial Geology

A portion of Wayne's glacial thickness map of Tippecanoe County (3) is shown as Figure 2. The existing roads transversing the area have been added to facilitate the location of local landmarks. This map, in addition to a glacial thickness map constructed by the authors from well-log and geophysical data, indicates that the maximum glacial cover in Section 35 lies in the southeast corner. This second glacial thickness map is shown as Figure 3. Toward the northwest, glacial deposits become more shallow where they overlie a high in the bedrock surface. The general stratigraphic section indicates till overlying glacial fluvial material. The deposits range in composition from clay to coarse gravel with intermediate mixtures of the two. There is considerable inter-

FIG. 3
GLACIAL THICKNESS MAP



bedding of outwash making correlation between wells extremely difficult.

Individual lenses of blue, gray and yellow till are interbedded with outwash material along the margin of the Hadley trough, where Homewood Addition is located. There appears to be some continuity of the glacio-fluvial material, but the composition varies from fine sand to coarse gravel. This composition indicates considerable deposition under periodic slack water conditions.

The glacial cover is observed to increase eastward from the Homewood area toward the Hadley Lake depression where the drift thickness reaches about 200 feet. An increase in the percentage of sand and gravel in this eastern section is also indicated which, coupled with the increased drift thickness, tends to yield more suitable water supply.

Bedrock Geology

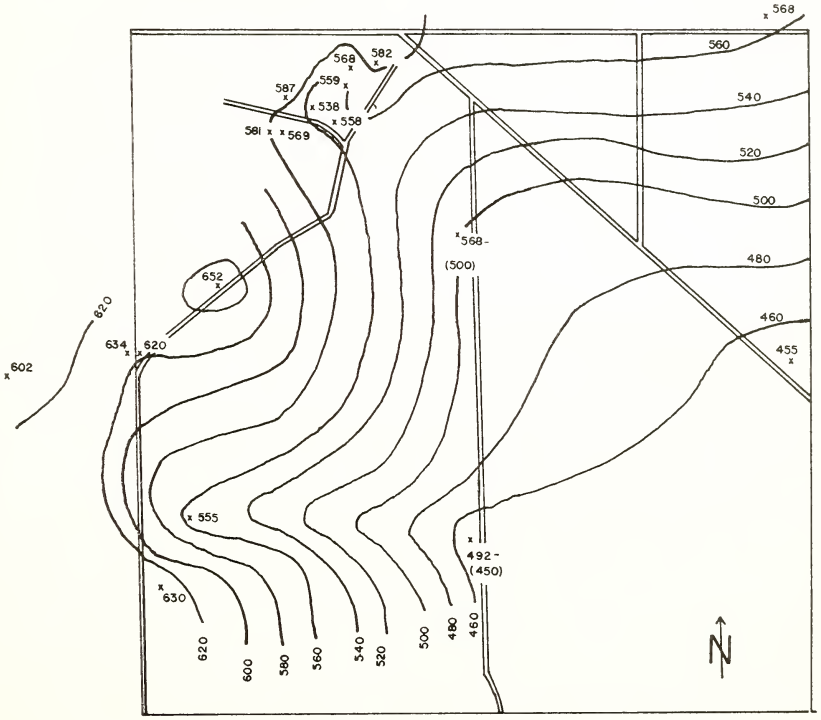
The bedrock underlying Homewood and vicinity is Mississippian age rock of the Borden group. The material observed at one well location in Homewood was a light gray, slightly calcareous, siltstone. Rosenshein (1) has described similar material as blue to gray, fissile shale which may be fossiliferous and pyrite bearing at some locations.

A bedrock map was constructed utilizing available well log data. This map is shown as Figure 4. Maximum relief on the bedrock surface is approximately 97 feet and the surface slopes from the northwest toward the southeast. The maximum elevation observed is 652 feet whereas the lowest is 455 feet.

Two valley systems are indicated on this bedrock map. One slopes eastward from an area about ½ mile south of Homewood whereas the second slopes southeast from the central portion of the Homewood area itself.

FIG. 4

BEDROCK CONTOUR MAP



CONTOUR INTERVAL = 20'

SEC 35, T 24 N, R 5 W.

The Groundwater Problem

A shortage of available groundwater in the Homewood area became apparent in 1960 when the first dry hole was drilled. Since that time six other attempts to obtain water in the subdivision have ended with the same result. The water shortage is also exemplified by the fact that several existing wells in the area are limited to a production of from 2 to 5 gallons of water per minute.

A map of the Homewood Addition is shown as Figure 5. The location of water producing wells and dry holes are indicated on this map. Homes have not been constructed to date on lots 7 through 10 so no well records are available in that region. A producing well is located on a neighboring farm just north of the intersection of Hebron Court and Union Road which indicates a suitable water supply in that general area.

Groundwater supply is notablypoorsouth of Homewood Drive. Five dry holes have been drilled to date in this region and the single producing well on lot 25 was obtained only after lengthly operations which may have included gravel packing of the well.

The area just north of Homewood Drive is somewhat better in that dry holes are not normally encountered in this vicinity. Water supply, however, is not as abundant here as in other parts of the housing area.

The largest producing wells in the subdivision lie near the circumference of Hebron Court. The well designated No. 12′ was test pumped at 150+ gallons per minute and has the greatest production in the area. This well currently supplies six houses and provisions are available for a seventh house on lot 15 when it is constructed at a later date. The location of the connecting waterline is shown by a dashed line which leads from the well location at 12′ to the problem area south of Homewood Drive.

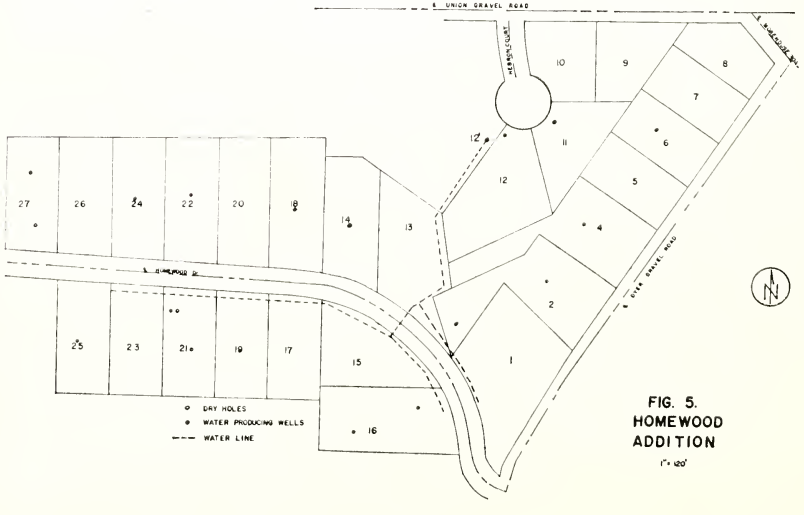


FIG. 5.
HOMEWOOD
ADDITION
1" = 200'

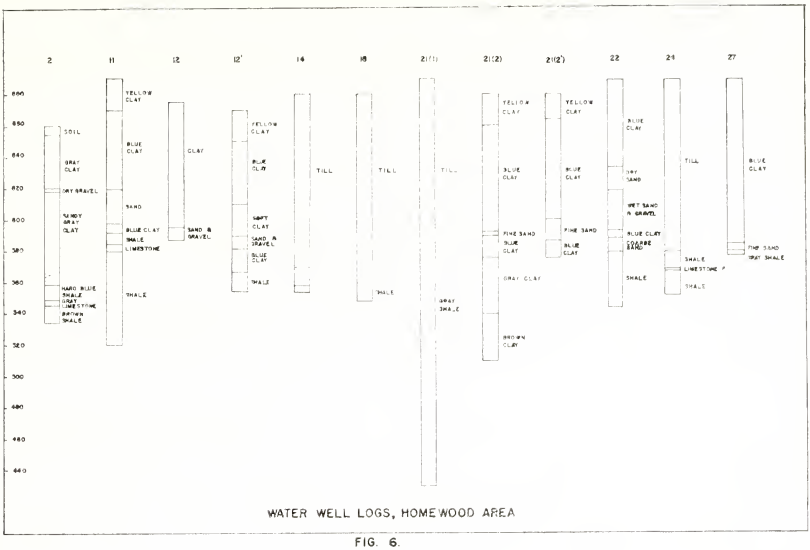


FIG. 6.

Well log data for the area are shown in Figure 6. Much of this information was obtained directly from the homeowners as well logs have not been recorded for all wells in the area. It can be observed that the depth to bedrock is of the order of 100 to 110 feet.

A contributing factor to the scarcity of available groundwater in the area of Homewood is the fairly thin veneer of glacial material at this location. The glacial thickness increases from approximately 100 feet at Homewood to an excess of 200 feet near Hadley Lake. This added thickness greatly improves the probability of finding a water-bearing, permeable zone in the drift which will yield an adequate water supply.

Groundwater and Subsurface Evaluation

Water supplies in the Homewood area are obtained primarily from glacial drift. Much of this water is pumped from coarse gravel, but coarse sands serve as acquifers for several of the wells. There is a definite lack of suitable acquifers in the drift owing to the presence of fine sands in many of the water bearing coarse sands and gravels. Filter costs prohibit the economic extraction of the water.

Several well logs on Figure 6 indicate limestone beds within the shale bedrock, usually at a depth of about 140 feet. Several of the owners of the wells in question have stated that their drillers claimed that this limestone bed was the water producing zone of the well. In other deep wells in the area, for one example 21a, this limestone was not intercepted. Owing to the fact that the Borden siltstone is calcareous in the area and its gray color may be confused with that of many limestones, the existence of this limestone layer is in some doubt and the possibility of it being an acquifer is questioned. The Borden group at this location is extremely tight and water production

from lenses within it are doubtful. However, more than one well driller has reported this rock member so that its existence should not be dismissed entirely.

The well driller who developed several of the bedrock-seated wells is known to have used perforated casing for these wells. This allows water to seep in from marginal water bearing zones and to accumulate in the bottom of the well. An exceptionally deep well into the bedrock would set up a collection reservoir from which the water could be pumped.

Many of the water supplies in the area are obtained close to the bedrock surface. Water appears to collect in the basal sands and gravels. In one case, difficulty in clearing the shale particles from the water was observed and the well was finally abandoned. Some fairly thick lenses of coarse, dry gravel are found in Homewood area. This indicates that these deposits are local in extent and probably are not connected with the main acquifer system.

Artesian wells are associated with all the acquifers in the area. These artesian conditions as well as the complex lensing of sands and gravels seem to indicate movement of groundwater between stratified layers. The lack of sand or gravel outcrops indicates that artesian acquifiers are recharged outside the vicinity of Homewood Addition and perhaps beyond the confines of section 35.

Coarse, clean, water bearing gravels are found at depth in the area around Hebron Court. In well 12′ the acquifer is located at a depth of 88 feet in this gravel. The fact that only a 20 foot drawdown occurred when this well was test pumped at 150+ gpm is evidence of abundant water. Well 12 only 40 feet away also has a generous flow of water.

The occurrence of this tremendous water production in the midst of the considerably more modest water supplies of the area is an interesting phenomenon. Examination of the glacial thickness map presented as Figure 3 shows a V-shaped finger parallel to the creek in the Homewood area and indicates an increased glacial thickness at this point. In addition, the bedrock contour map shown as Figure 4 indicates a valley in the bedrock surface in the vicinity of well 12′.

As previously stated the area east of Homewood has a thicker glacial cover which contains greater percentages of water-producing sands and gravels. It is suggested on the basis of current evidence that a protrusion of this deposit extends into the Homewood area and is intercepted by the large production well.

The water problem in the remainder of the subdivision is brought about by a two fold situation, the thin veener of glacial cover and the low percentage of water producing zones in this limited thickness. An impermeable bedrock material completes the bleak subsurface situation in regard to groundwater supply.

Recommendations

The groundwater problem described in this report is one which could occur in many glaciated areas of the United States. The

heterogeneous nature of ice contact glacial deposits is such that problems of this nature may be fairly common.

An object lesson can be derived from this example problem. A thorough investigation concerning groundwater supply would not have alleviated the problem but would have lessened the concern of the prospective home owner who inadvertently began house construction only to learn of water supply problems at a later time.

The development of the Homewood Addition was such that a single water system for the entire area was not possible. Since the lots were sold on an individual basis with no overall construction firm involved, water supplies were developed individually as well. Under different circumstances a community well would have best served the purpose.

A limited community well was established in Homewood out of desperation after the surprisingly high production well, 12', was obtained by an individual owner. Other land owners located in possible problem areas were invited to join the venture. This proved to be an excellent solution to the problem but a great deal of luck was involved for all parties involved in this water find.

As a suggestion to those who are confronted with the problem of building a home beyond municipal water mains the following suggestions may be applied.

1. Investigate the water situation in the area by inquiring with existing home owners and by checking available literature. Universities and the State Geological Survey can be consulted for advice.
2. Do not initiate construction until a producing well has been obtained on the land.
3. If possible, obtain an option on the land until a producing well is gotten, then purchase the property and initiate construction.

Acknowledgments

The authors wish to thank the property owners in the Homewood Addition for their cooperation in supplying well log information which formed much of the basic data for this report. Recognition is made also of the efforts of Mr. M. A. Waldman who prepared the illustrative material.

Literature Cited

1. Rosenshein, Joseph S. 1958. Ground Water Resources of Tippecanoe County, Indiana; Division of Water Resources, Bulletin No. 8.
2. Schneider, Allan F., Gerald H. Johnson, and Wm. J. Wayne, 1963. Some Linear Glacial Features in West-Central Indiana. Abstract of paper not published in full, Proceedings of the Indiana Academy of Science, **72**.
3. Wayne, Wm. J. 1952. "Map of Tippecanoe County, Indiana, Showing Thickness of Glacial Drift." Miscellaneous Map No. 2.

Structural Mapping by Means of Mississippian Corals in West-Central Indiana

C. L. Bieber, DePauw University

The regional structural pattern of West-Central Indiana is characterized by middle Mississippian limestones dipping gently at approximately 30 ft./mile southwesterly towards the Illinois Basin. This pattern is established by limited deep-bores, magnetic charts (which probably reflect the basement complex) and other geophysical data, and surface mapping. Marker horizons to serve reliably for mapping structural detail in the Mississippian sequence from lower Harrodsburg limestone upward through the Ste. Genevieve limestone are difficult to establish. Some of these markers are set forth in the following paragraphs, and one of them is singled out as an example.

A lithologic break in the Upper St. Louis limestone can generally be recognized in Putnam County. Here thin-bedded, sometimes cherty, bryozoan-rich beds stand in contrast to the massive light gray Ste. Genevieve limestone above. However, recurring fossiliferous zones above or below this lithologic break may locally hide the true horizon.

Chert layers are common to the St. Louis limestone. The cherts are more rounded below, while above they are flat-lying fossiliferous replacement types. The cherts are not uniformly placed laterally or vertically and thus are not reliable as mapping markers. Intraformational conglomerates are likewise widely scattered both vertically and horizontally (1). Colors of the various formations also fail, though the lower St. Louis limestone is mostly darker gray as compared to the monotonous light grays above and below.

Fossils hold some hope as being useful in establishing mapping horizons, since they are plentiful and of great variety. Brachiopods and crinoid fragments are fairly abundant, but not diagnostic. Parts of columnuls of crinoids such as those of *Platycrinus penicillus* are confined mainly to the Ste. Genevieve limestone but are of too great a vertical range to be useful for markers in detailed mapping. The abundant fossil bryozoans of the upper St. Louis limestone make an horizon about 10 to 15 ft. thick. This horizon is useful, but again other bryozoan layers may occur through the sequence to mislead even the careful observer. A small sub-planispiral gastropod (cf. *Straparolus)* is fairly reliable for Salem horizons, as is the protozoan *Endothyra baleyi. Endothyra* is not abundant in many outcrops in Putnam County.

Fossil corals are scattered consistently through the limestone sequence. Cup corals, because of their great similarity one to another, need more detailed study before being usable for mapping. Large coral heads of *Syringopora* are common in middle Mississippian limestones of this area, especially in the St. Louis and Ste. Genevieve limestones. *Lithostrotionella proliferum*, finger-like rugose corals, are common to St. Louis horizons. These corals may be so thickly congregated (as near Greencastle)

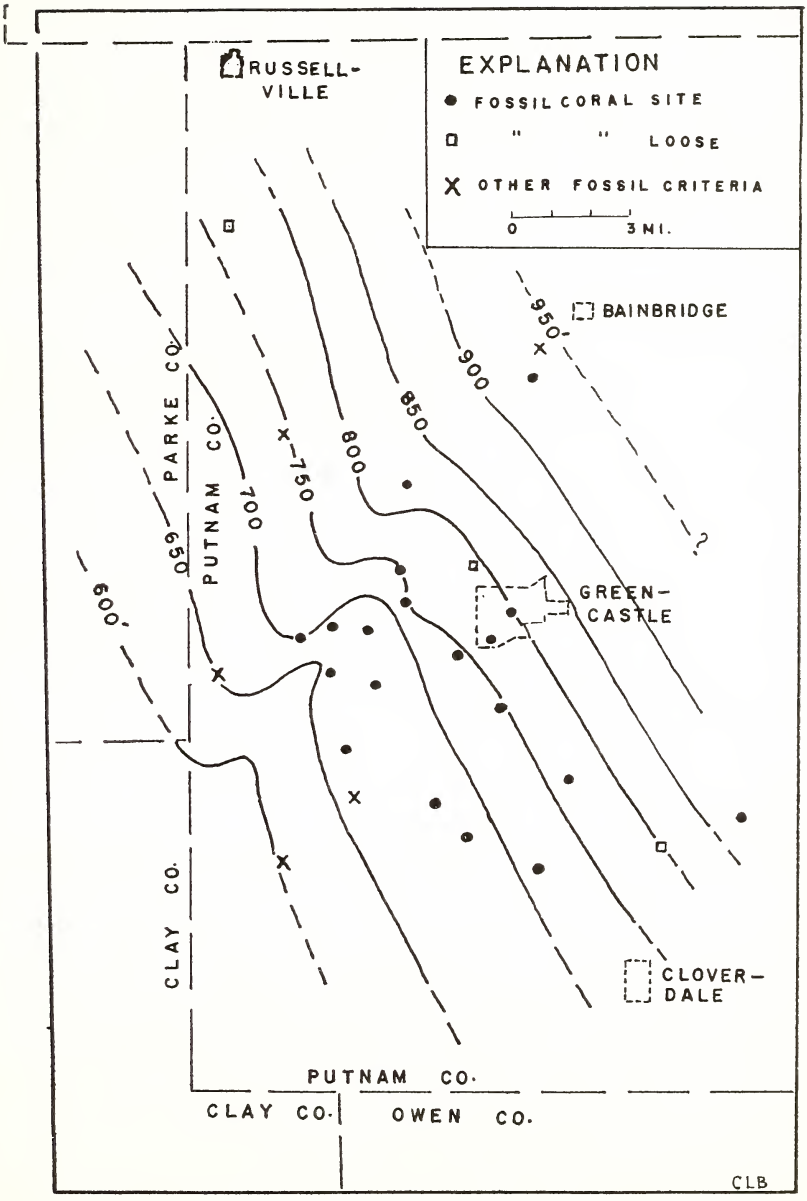


Figure 1. Fossil coral sites in Putnam County, Indiana.

in one bed as to constitute a biostrom. *L. proliferum* is confined to the St. Louis limestone. Fragments of the corallites, often silicified, are commonly scattered through the upper 50 ft. of the formation.

The fossil coral of greatest use as a stratigraphic and structural marker is *Lithostrotionella canadense* (3). Though close relatives of this fossil are widespread (2), and range through several geologic periods, *L. canadense* is narrowly confined in this area. Coral heads of this species are closely packed to sparingly scattered 2 to 10 ft. above the bryozoan-rich layers of the St Louis limestone (actually in the lowest Ste. Genevieve, on the basis of lithology). This coral is considered reliable in position as interpreted from the locations of "in place" collections. The vertical range is but a few feet in Putnam County. This fossil coral is difficult to spot if both fossil and matrix are of crystalline limestone. However, if the fossil is silicified or partly so, which is often the case, the darkness of the silicification provides a color contrast. Too, weathering of the limestone surface may provide enough contrast to lead to discovery of the geometric cross section pattern of the corallites. Careful scrutiny of the under edges of limestone ledges may help in location of the fossil. Rocks associated with the fossil coral are fine to medium light gray limestones.

A sample map interpretation has been prepared (Fig. 1). Nineteen different locations of *Lithostrotionella canadense* found in place have been mapped. Elevations for these locations were estimated from contours on topographic maps of the area. On these estimated elevations structural contours have been drawn on the *L. canadense* horizon, which represents the approximate base of the Ste. Genevieve limestone.

If future work proves this fossil coral, *Litrostrotionella canadense,* to be confined to as narrow a vertical range as present field work suggests, further work with this fossil may be useful in mapping structural detail.

Literature Cited

1. Bieber, C. L. 1958. Some Mississippian limestone breccias in northwest Putnam County, Indiana. Proc. Ind. Acad. Science. **68**:285.

2. Kelly, W. A. 1942. Lithostrotiontidae in the Rocky Mountains. Jour. Paleo. **16**:351-355.

3. Ulrich, E. O. and W. S. T. Smith, 1905. The lead, zinc, and fluorspar deposits of Western Kentucky. U. S. Geol. Survey Prof. Paper 36:33.

Variation of Iron Sulfide Content in Sphalerites of Mississippi Valley Deposits

JOHN H. CLEVELAND, Indiana State College[1]

Geothermometry has long been an inexact field because of the problem of multiple variables. The use of liquid inclusions for determining temperatures of mineral deposition most nearly approaches the ideal method for low and medium temperature ranges. The corresponding science of geobarometry, is even less well developed.

Liquid inclusion temperature data on sphalerites of the Mississippi Valley deposits is extensive. Kullerud (7) has shown by means of a detailed investigation of the FeS-ZnS system at high temperatures that the solubility of FeS in spalerite is a function of the temperature of formation. (The incorporated iron causes an increase in cell dimensions directly related to the amount of iron introduced.)

Pressure correction data are available for both the correction of liquid inclusion temperature determinations and those of the FeS-ZnS system.

The purpose of this investigation was to determine the FeS contents of Mississippi Valley sphalerites and compare them with liquid inclusion temperature values. It was hoped that the work would shed light on pressures of low temperature FeS-ZnS temperature determinations, and on the variability of iron content within the spalerites of Mississippi Valley deposits.

Specimens of sphalerite, previously studied by the liquid inclusion method, from the Upper Mississippi Valley district, Wisconsin-Illinois (1), the Deardorff mine, Cave-in-Rock district, Illinois (5), and the Miami-Picher district, Oklahoma (9) were made available to the writer for this study. X-ray spectroscopy was chosen as the method of determining iron content because of the small amount of sample required in this technique and its high accuracy in the anticipated range of iron content.

Previous Work — Liquid Inclusions Studies

Bailey and Cameron (1) reported temperatures ranging from 121° to 75° (uncorrected for pressure) for the sphalerites of the Upper Mississippi Valley district. Their results suggested that, in general, temperatures declined progressively during sphalerite deposition. From study of the liquid inclusions in the Deardorff mine in the Cave-in-Rock district Freas (5) reported liquid inclusion temperature values of 103° to 84° (uncorrected for pressure) for sphalerite. Schmidt (9) studied sphalerite from the Miami-Picher district and found liquid inclusion temperature values ranging from 120° to 83° (uncorrected for pressure). The techniques employed in these investigations and an evaluation of the liquid inclusion method were given by Bailey and Cameron (1). The reader is referred to their paper.

[1] Material in this paper formed a portion of a master's thesis prepared under the direction of Professor E. N. Cameron at the University of Wisconsin, 1959-1961.

FeS-ZnS Geothermometer Studies

The sphalerite from the districts named above varies considerably in color and shade, commonly within a single specimen. Sphalerite specimens consisting of successive bands are generally lighter toward the centers of veins but reversals are not uncommon (Fig. 1). The variations in shade have been considered to be due to variations in iron content. Kullerud (7) gave FeS-ZnS temperature values for a group of specimens from Mississippi Valley deposits. The values suggested much higher temperature ranges for sphalerite deposition than indicated by liquid inclusions (up to 245°, uncorrected for pressure).

Similar studies using the FeS-ZnS geothermometer have been made by Fryklund and Fletcher (6) and Benson (3). Bradbury (4) has made spectographic determinations of sulphide minerals from the Upper Mississippi Valley district that augment this study. His Fe values determined for six sphalerite specimens from the Bautsch mine are in agreement with the results of this study.

General Geology — Upper Mississippi Valley District

This district is located primarily in the southeastern corner of Wisconsin but extends into the adjacent states of Iowa and Illinois. The area is underlain by gently dipping Ordovician limestones, dolomites and shales. The mineralized section is approximately 400 feet thick.

Structural variations consist of minor west-trending anticlines, subsidiary elliptical folds striking east-northeast and northwest, and local faults with displacements up to 50 feet. The ore deposits appear to be controlled by the smaller subsidiary folds that have been accentuated by solution thinning of the carbonate beds. The deposits are separated into "top run" and "bottom run" types. The latter are composed of disseminated and vein ore bodies in the lower section of the mineralized zone. Vein ore bodies are termed "pitches" where they follow steeply-dipping fractures and faults, and "flats" where they occur along bedding plane fractures and faults.

Galena and sphalerite constitute the major ore minerals. Lesser amounts of chalcopyrite, gold, millerite and silver have been found. The major gangue minerals are calcite, dolomite, marcasite, pyrite and quartz. Barite and akermanite are present. More detailed descriptions of the district are to be found in Bailey and Cameron (1) and Behre et al (2).

Deardorff Mine, Cave In Rock District

The Deardorff mine (W. L. Davis-Deardorff mine) lies northwest of the town of Cave-in-Rock in southeastern Illinois. The district is underlain by gently dipping Mississippian and Pennsylvanian limestones, shales and sandstones. Igneous dikes are present in one part of the district, but do not appear to be related to the ore deposits. Economic mineralization is largely limited to a stratigraphic interval of 200 feet within the Mississippian limestones. The deposits occur in favorable horizons, most abundantly where these horizons are intersected by joint fractures and pre-mineral faults. Small synclines, probably caused by solution thinning and collapse breceia, mark many of the bedding replacements deposits.

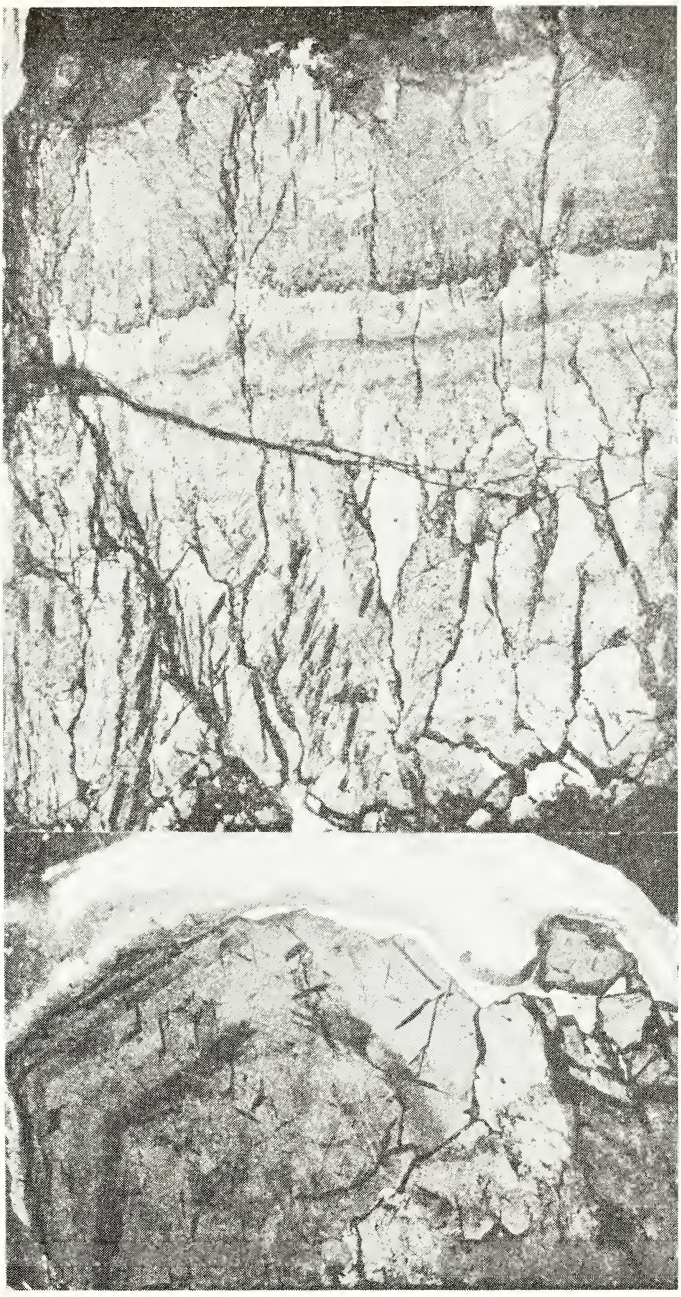


Figure 1. Photograph of a polished section of banded sphalerite from the Liberty mine, Wisconsin. 4x, transmitted light.

Figure 2. Photograph of a polished section of discontinuous banding sphalerite from the Deardorff mine. 4x, transmitted light.

In addition to fluorite, for which the district is noted, the Deardorff mine produces important quantities of galena and sphalerite. Figure 2 illustrates typical sphalerite from this mine. Accessory and gangue minerals include calcite, quartz, barite, chalcoyrite, pyrite, marcasite, witherite, strontianite, cerussite and malachite. A more detailed account of the geology is to be found in Weller et al (11).

Miami-Picher District

The Tri-State region, of which the Miami-Picher district is the southwestern part, is made up of several scattered mining centers in an area 125 miles long and 50 miles wide at the intersection of Missouri, Kansas and Oklahoma.

The deposits occur in a stratigraphic interval of 400 feet within the flat lying Boone formation of Mississippian age. The mineralized beds consist of limestone, shaly limestone and chert. The primary structural feature of the district is the Miami Trough, a 40-mile-long synclinal depression trending east-northeast that is only 1,000 feet wide with less than 200 feet of vertical displacement. A few deposits occur along the trough. Most mines lies southeast of the trough, however, beyond its structural limits but well within the zone of intense fracturing and brecciation. The deposits commonly have a linear trend following steep fractures or irregular solution channels. Blanket deposits occur in favorable beds. Gangue and ore minerals replace the limestone of favorable beds leaving the chert relatively unaffected. The chief ore minerals are sphalerite and galena. The chief gangue minerals are dolomite, jasperoid and calcite. Accessory minerals include marcasite, chalcopyrite, pyrite, enargite, and barite. For further details of the district geology see Behre, et al (2).

Results

Table 1 is a summary of the results obtained in this study. Specific observations based on this data include:

1. The Miami-Picher district sphalerite liquid inclusion temperature values range from 80° to 115° but the FeS% does not exceed 0.14%. This suggests that the amount of FeS present during the formation of sphalerite may have been very low and that significant variation in FeS content could not take place. The small amount of pyrite contemporaneous with this sphalerite is in agreement with a low iron environment of deposition.

2. The data from the other areas sampled indicates only the crudest tendency for FeS content to decrease with decreasing temperature.

3. Correlations of FeS percentages and the shade of sphalerite within individual specimens from the Upper Mississippi Valley District is reasonably good but not without inconsistencies.

4. Correlation of a set of layers in several specimens of sphalerite occurring at different locations in one mine by means of iron content determinations seems feasible.

TABLE 1
Summary of Liquid Inclusion Temperature Values and FeS Weight Percentage Determinations for Sphalerite

Mine	Upper Mississippi Valley			Miami-Picher	Total
	Andrews	Bautsch	Liberty	Deardoff		
Number of specimens	6	7	8	6	15	42
Number of samples	30	24	27	17	23	121
Number of samples with FeS weight % values	27	22	25	17	23	114
Number of samples with temperature values	13	18	18	7	17	73
FeS Weight % values						
Minimum and maximum	0.12-2.08	0.10-2.20	0.10-1.02	0.61-0.92	0.04-0.14	
Average	0.64	0.82	0.39	0.74	0.08	
Liquid inclusion temperature values (°C).						
Minimum and maximum	75-103	69-110	73-98	82-128	80-115	
Average	91	94	86	92	100	

Conclusions

Based on the FeS determinations and the related light inclusion temperature data, the following statements and conclusions can be drawn.

1. The FeS% in this study of 114 samples of sphalerite taken from 40 specimens ranged from 0.04% to 2.20% by weight. The maximum FeS content for sphalerite formed at a temperature of 138° in equilibrium with FeS_2 was estimated by Kullerud to be about 3.7% (6). Later corrections by Skinner and others (10) suggest that even this figure may be too low. Thus the FeS content of the studied specimens gives no indication of temperatures higher than those given by liquid inclusion determinations and to this extent the data on FeS contents serve to support these determinations. The darker bands of the Upper Mississippi Valley district for which there are no liquid inclusion determinations are 0.4% to 0.5% higher in FeS% than the bands giving maximum measured temperature values. This increase, about one-fourth of the total temperature variation, suggests that the temperature of formation of sphalerite of the darker bands would be near the 128° maximum found by liquid inclusion study.

2. Kullerud's FeS% determinations of sphalerite samples from Mississippi Valley type lead-zinc deposits are at variance with the determinations made in this study. Seven of his ten determinations exceed the maximum values found in this study and range up to 6.22%. Furthermore, these high values are not supported by the liquid inclusion data. Quite possibly contamination of the sphalerite samples with small amounts of included pyrite may account for Kullerud's anomalously high values.

3. The poor correlation of the FeS% and the liquid inclusion temperature determinations in a given sample does not permit the establishment of any direct fixed relationship between the two even for individual mines and precludes the possibility of pressure determinations based on these two lines of inquiry in this study.

4. The FeS% of the sphalerites in the deposits studied are not dependent upon temperature of formation as shown by the lack of direct correspondence between liquid inclusion temperature values and the FeS%. This is not surprising in that there is no evidence that sufficient FeS was available in solution to saturate the sphalerite lattice. Kullerud gives the presence of pyrrhotite as positive evidence for such conditions of saturation, but pyrrhotite does not occur in these deposits. Kullerud and others (8) have experimentally determined the curve for equilibrium with pyrite. This curve is sufficiently higher than the ZnS-FeS curve at moderate temperatures permitting considerable variation in FeS content independent of temperature and dependent only on the amount of iron available in relation to sulphur. The evidence gathered from this study suggests that the use of FeS content variation of sphalerite as a precise geological thermometer, especially under low temperature conditions, is subject to question because of factors (chiefly abundance of FeS ion) other than temperature controlling the variation.

5. The lack of significant FeS% variations and any apparent relationship between probable temperature of deposition as shown by liquid inclusion data in the Miami-Picher district suggest that there was insufficient FeS available to enter the lattice of the sphalerite in amounts much above 0.14% regardless of the ability of the lattice to take up more FeS.

Literature Cited

1. Bailey, S. W. and E. N. Cameron. 1951. Temperatures of mineral formation in bottom-run lead-zinc deposits of the Upper Mississippi Valley, as indicated by liquid inclusions. Econ. Geology **46**:626-651.
2. Behre, C. H., Jr., A. V. Heyl, and E. T. McKnight, 1950: Zinc and lead deposits of the Mississippi Valley. International Geological Congress, 18th Session, 1948 **7**:51-69.
3. Benson, David, 1960. Application of the sphalerite geothermometer to some northern New Brunswick sulphide deposits. Econ. Geology **55**:818-826.
4. Bradbury, J. C. 1961. Mineralogy and the question of zoning, northwestern Illinois zinc-lead district. Econ. Geology **56**:132-148.
5. Freas, D. H. 1961. Temperatures of mineralization by liquid inclusions, Cave-In-Rock flourspar district, Illinois. Econ. Geology **58**:542-556.
6. Fryklund, V. C., and J. D. Fletcher. 1956. Geochemistry of sphalerite from the Star Mine, Coeur D'Alene district, Idaho. Econ. Geology **51**:223-247.
7. Kellerud, Gunner. 1953. The FeS-ZnS system; a geological thermometer. Norsk Geol. Tidsskr. **32**:61-147.
8. Kellerud, Gunner, H. S. Yoder, and R. E. Arnold. 1957. The Fe-S system. Ann. Rept. of the Director of the Geophysical Laboratory, Carnegie Institution of Washington. 181-183.
9. Schmidt, R. A. 1962. Temperatures of mineral formation in the Miami-Picher district as indicated by liquid inclusions. Econ. Geology **57**:1-20.
10. Skinner, B. J,. P. B. Barton, and Gunner Kellerud, 1959. Effect of the Fe-S on the Unit cell edge of sphalerite: a revision. Econ. Geology **55**:1040-1046.
11. Weller, J. M., R. M. Grogan, and F. E. Tipple, 1952; Geology of the fluorspar deposits of Illinois. Illinois Geol. Surv. Bull. no. 76.

Historical Background — Wisconsin Population Distribution

ELMER B. HESS, Valparaiso University

The westward movement of settlers from the Atlantic seaboard into the virgin lands beyond the Appalachian Mountains is epochal in American history. The pioneers of early American stock were joined by foreign immigrants and these two groups pushed westward into the new land.

The French Regime: 1634-1763

The first white man to set foot upon the territory which was later to be included within the boundaries elected to limit the Wisconsin Territory was Jean Nicholet. His journey illustrates how the lakes and tributaries from the early exploratory days directed people toward Wisconsin.

There were manifold motives that directed the pioneer into the midwest. To some the impelling motive was a search for a passage across the North American continent to the Pacific. To others exploration was secondary to the diplomatic services they might render in securing furs. Still others hoped to find gold and silver mines and to duplicate the wealth of the Spanish.

The traffic in furs was of such importance that the profitable returns stimulated the traders to penetrate farther into the interior of the country. The traffic in furs led to an exploitation of the Indians which was in some ways detrimental to them; but the traders rendered a valuable diplomatic service in preparing a way for the people who were to come later. They constituted the vanguard of the miners and agriculturalists who were to follow.

British Period

With the fall of Quebec to the British in 1760 French sovereignty in Wisconsin was virtually ended, but the change to British control altered only slightly the fur industry. The British set up trading posts and invited the Indians to bring furs in exchange for rifles and trinkets. Under this plan another step toward the permanent occupation of the land had been taken.

After 1763 there began a steady stream of frontiersmen who cut away the forest and established permanent settlements as soon as, and even before, the land was acquired from the aborigines.

American Period

The treaty of Paris of 1783 which transferred control of Wisconsin from British control to American control was merely a scrap of paper as far as reality was concerned. During the period which elapsed between 1783 and 1816, British and American interests were often at odds in this territory, but following the War of 1812 Wisconsin became under effective American control.

The first settlements: By 1820 the white population of Wisconsin had begun to localize in one or two places. This fact made possible an estimate of the actual number of permanent settlers. In 1820 Green Bay and Prairie du Chien were the only important settlements in Wisconsin. The former consisted of about 60 houses and population of perhaps 500 besides the garrison of soldiers. Prairie du Chien, the other settlement, had approximately 600 settlers including 100 soldiers.

Sectional Settlement of Wisconsin: 1820-1900

The early settlement of Wisconsin can best be discussed by dividing the state into five divisions: The Lead Region, the Eastern Ridge region, the Central Plain, the West Upland and the Northern Region. These divisions are based partly on physiographical features and partly on the historical development of settlement.

The Lead Region: Unified by the presence of mineral resource, the region of the Upper Mississippi River Valley known as the Lead Region has had a special history. That part of Wisconsin included within the borders of the Lead Region has shared in this history.

A few miners reached Wisconsin in 1820, but it was not until 1825 that the frenzied movement into the area began. As the frontier of settlement approached the lead region, the pioneers attracted by the prospect of wealth threw out a salient in advance of the agricultural frontier. One significant fact concerning the early settlement of the southwestern part of the state was the direction of the movement. The laws which generally confine the migration of the human race to isothermal zones were set aside and the emigrants from the mild climate of Tennessee, Kentucky, and Missouri exchanged a mild climate for one in which during nearly half the year all nature is bound with ice and snow. In this is found the explanation of the fact that so many people of southern origin found their way into southwestern Wisconsin; they had been attracted by the lead and were guided by the Mississippi River into the mineral lands.

About 1830 there began a stream of miners from Cornwall, England, that has left in the lead region thousands of descendants. It is estimated that in 1850 there were about 6 thousand native Cornish in Wisconsin.

Many came to the lead region of the upper Mississippi valley to mine lead but remained to farm when the agricultural frontier had ovetaken them. The fertile upland prairies were easily made productive with wheat and corn as important crops. The ease with which the land could be farmed brought the prairies into competition with the lead as a dominant element of the environment.

Eastern Ridges and Lowlands: Southeastern Wisconsin as a regional division has come to mean that portion of the state having the highest economic development and containing within its indefinite borders the major portion of the population. The region is not everywhere naturally delineated, nor has it the same combination of physical conditions over the whole area; but the distribution and the concentration of the inhabitants gives it sufficient unity to warrant regional analysis.

Within the region known as southeastern Wisconsin there were two early settlements. Green Bay, the most important, was situated strategically near the mouth of the Fox River. In 1634 Nicolet ascended the Fox River which later became the natural route to eastern Wisconsin. The orientation of the natural waterways from the eastern sea coast directed population into the Fox Valley. It is only logical that a military post should have been erected at the Fox River mouth.

The settlement of southeastern Wisconsin after 1832 is epochal. The lead region was first settled by a final wave of great migration; but it was not until after 1832, when the danger from Indian attack had been ended, that the southeastern portion of the state was opened to settlers. The end of the frontier struggles and the "hard times" in the eastern cities combined to stimulate a new wave of migration.

After 1832 the southeastern part of Wisconsin began to tap the stream of western migration and by 1850 most of the area from Lake Michigan to the Lead region and northwestward toward the Fox River was settled, and the frontier moved on by 1850 across the Fox and Lower Wisconsin Rivers. The indefinite boundary between the settled and the unoccupied lands was a progressively shifting agricultural frontier. The westward and northward movement of the frontier up to 1850 had left behind it over 90 per cent of the total population or 287,730 settlers including 37,225 in the lead mining region of the southwest.

The newcomers distributed themselves over southeastern Wisconsin as a thin film of population. They entered first the better lands in the southern tiers of counties where the open prairie offered attractive conditions to the pioneer. Where the prairies were too extensive, the central portions remained unoccupied for a few years. The borders of the prairies offered an ideal combination of woodland for fuel and building materials and a prairie area for plowland.

The value of any area for agricultural purposes is largely determined by the natural landscape—soil and climate—and by proximity to other areas and ideas. But even under almost ideal environmental conditions a region might remain undeveloped. The land of any area is important for the human opportunity it represents, but the use which is made of the land depends upon the people who come into their possession.

In southeastern Wisconsin there has developed a sectionalism where the conditions of the physical landscape were more or less uniform except for a difference in the natural vegetation. The southern part of this area was characterized by the open oak forest with extensive prairies. Just to the north of the southern tier of counties was a hardwood forest of maple and of some oak and beech.

In the settlement of southeastern Wisconsin there was enacted what may be called an experiment in historical geography. The southern division was settled by the eastern Americans and British and the forested section by Teutons. These homeseekers were not destitute, and with the credit extended to them by friends the purchase of a farm was looked upon as a method of creating an estate. Large farms were the rule.

The number of Germans in Wisconsin before 1950 formed an important nucleus which determined the population conditions in the forest sections of eastern Wisconsin. Because these German immigrants were at the bottom of the economic ladder they settled in the woods. They could not afford to encounter the risk of taking ideal farm land in the Congress Land district, nor could they afford to buy such land from speculators. The Germans who settled in the rural communities generally purchased small farms from 40 to 80 acres. This centralization had the effect of creating a dense rural population in the area which was originally a maple forest. Even today no section of Wisconsin has so dense a rural population as this German settled section.

In a generation or two the forest has been removed and the two sections were essentially vegetatively the same. Both the German settled section northwest of Milwaukee and the Yankee settled strip along the southern tier of counties present a cultural landscape of beauty and properity.

Northern Wisconsin: The westward march of the frontier across the United States by-passed northern Wisconsin. In the 1870's the population of the state increased 24.7 per cent; Iowa showed an increase of 36.1 per cent, Minnesota gained 77.6 per cent. It is evident that the advance into Wisconsin had been slowed down. The northern part of the state lies off the principal highways followed by the home seekers. Furthermore the prairie land to the west offered greater opportunities to agriculturalists than did the heavily forested land to the north.

In northern Wisconsin the advance of the series of frontiers did not follow either in point of time or in type the sequence in southern Wisconsin. The frontier of the hunter and trader had a longer lease of life and reluctantly gave way before the cutting edge of the lumberman's frontier. For almost half a century the pioneer woodmen extended their salients up the rivers and later along the railroads until the forest was separated into isolated areas of pine.

During the period from 1850 to 1880 the movement of population into Wisconsin completed the agricultural settlement of that part of the state underlain by Paleozoic rock. In the forested northern highlands thin threads of settlement followed the rivers, road and railroads leaving isolated blocks of untouched wilderness. By 1880 the frontier of settlement had crossed Wisconsin, but within the state there remained wilderness sections around the periphery of which the frontier slowly encroached and penetrated.

The westward movement involved the wasteful removal of the forest to prepare land for agriculture. This was the guiding principal as the frontier marched northward. But as the frontier advanced, the destruction of the forest did not leave in its wake farm land of such high potential value as in the southern part of the state. The idea of conservation came too late to save a part of the forest on land unsuited for agriculture. Because of the lack of easily cultivated prairies, the low intrinsic value of the land, and the severer climatic conditions, the agricultural frontier passed very lightly across the northern part of the state leaving in its wake only a very sparse population.

The settlement of the prairie areas of the Mississippi and Missouri Valleys created a demand for lumber which the Upper Lake country supplied. The removal of the forest for its lumber content was the principal motive in clearing the land, and not its agricultural value.

Just as the fur trader pioneered into the wilderness of northern Wisconsin, the lumbermen overlaid a new industry on the site of the old. The settlement of the treeless prairies of the upper Mississippi River created a demand for lumber. The Wisconsin and Mississippi rivers and their tributaries not only drained water from the pine covered northern Wisconsin, but also conveyed the lumber into the prairie boom. For forty years lumbering was the dominant interest in the northern half of the state. Along the rivers hundreds of saw mills arose, and around these mills grew the lumbering towns such as La Cross, Oshkosh, and Eau Clair. Coincident with the development of the lumber industry and necessary to its successful prosecution was the development of extensive railroad networks. The railroads brought the "piny" within easy reach of the markets.

The Central Plain: The central plain is a conspicuous physiographic region in the central part of Wisconsin. The original pine forest made the area much like the glaciated portion of the northern highland and in a similar way has retarded the agricultural invasion of the area.

The region is infertile by southeastern Wisconsin standards and offers only slight opportunities for agriculture. It was the first barrier to the settlement of the land to the north.

The sandy central low land had patches of silt loams within the larger areas of sand, and a few farmers who were fortunate in the location of their farms were reasonably prosperous. There were, however, hundreds of farmers who abandoned their farms after a few years' trial, and recently the question of taxes has become serious.

Western Upland: The topography of the western upland is a gently rolling plain with locally capping limestone which has preserved wide interstream areas well suited to intensive agricultural development. Originally the region was covered by a hardwood forest except for a strip of prairie land along the uplands toward the north.

In 1850 there were about 9000 people in the part of the Western upland which lies beyond the lower Wisconsin. An examination will show that there was a wave of settlement that progressed northwestward across the upland. The more southern counties were settled in the decade of the 1850's, the central portion in the 1860's and 1870's, and the more northern region in the 1880's.

It is evident that the hilly Western Upland did not retard settlement, but its ruggedness has kept the density of the rural population below that of the southeastern part of the state. Furthermore the Western Upland lies on the wrong side of the state to benefit from the commercial activities dominant along Lake Michigan and thus is handicapped under modern economic conditions.

HISTORY OF SCIENCE

Chairman: A. T. GUARD, Purdue Universty

NELLE COATS, State Library, was elected chairman for 1965

Early Fields Trips of the Indiana Academy of Science. ARTHUR T. GUARD, Purdue University.—A brief review of the spring meetings of the Indiana Academy of Science shows that these meetings began in 1886 and have been held with few interruptions up to the present time. Each meeting was held near one of the areas of natural interest in the state. The field trips were spent exploring these areas. It is of special interest to note that many of the men attending these meetings were not only scientists important in local and state scientific circles, but they were also individuals with national and international reputations. David Star Jordon, John M. Coulter, C. R. Barnes, T. C. Mendenhall and many others of like scientific stature participated in the early meetings. Many of the places visited have since become state parks.

Three-quarters of a Century of Biology at Purdue University: 1874-1947

Raymond E. Girton, Purdue University

Purdue opened in 1874 with Abraham C. Shortridge as president. The staff member who represented biology was John Hussey, Professor of Botany and Horticulture, later Professor of Natural History. An ambitious curriculum for students selecting the Natural-History option included general chemistry, geology, descriptive botany, and trigonometry in the first year; physiological, systematic, and structural botany, entomology, chemistry, economic and cryptogamic botany, and zoology the second year; astronomy, plant distribution, zoology, botanical microtechnique, economic geology, and paleontology in the third year; and zoology, paneontology, fossil botany, minerology, experiments in plant fertilization, herbarium work, and the relation of entomology and botany in the fourth year.

In the Purdue University Register (1) for the year 1874-75 we read: "The instruction in Botany will embrace all the principal branches of this science. After three terms of descriptive and systematic Botany, the student will be expected to do laboratory work, making use of the miscroscope in Cryptogamic Botany and the study of the physiology of plants; proceeding to experiments in fertilization and to special topics. Herbarium work will be required throughout the entire course."

The following year (1875-76) the "Annual Circular" (2) tells us: "Structural and Physiological Botany, same as in the general course, with the addition of the more recondite facts and principles, including the character and relations of parts of seeds, morphology, facts and methods of fertilization, origin of tissues, relations of plants to animals, species, etc."

Two years after a slow start for the University a new president, Emerson E. White, took office. A general reorganization of the curriculum now took place. Six Schools of Science and Technology are listed in the "Annual Circular" for 1876. The School of Natural History taught by Professor Hussey offered instruction in the Divisions of Botany, Zoology, and Geology.

Professor Hussey resigned in 1880. A student tribute to him reads as follows (3): "I remember Professor Hussey with both affection and gratitude. My association with him as a student awakened an interest in the world about me which has increased with the years and has made life the richer for it." Professor Hussey was followed by Charles R. Barnes who in the "Annual Register" for 1880-81 (4) is listed as Instructor in Botany, Zoology, and Geology. Instruction in fundamental biology and in botany (classification, anatomy, and physiology) was offered to freshmen: in zoology viz. histology, embryology, and classification to sophomores; and in physiology and anatomy to seniors. Special work aside from regular course work was offered in botany. Two herbaria of over 3,500 plants and a zoological museum were stated to be available for use by students.

In the "Annual Register" for 1882-83 we learn that students in the "School of Biology" elected either botany or zoology in the middle of the second year. Six courses and a thesis are listed for botany majors and four courses and a thesis for the zoology majors. In 1883 President White resigned over the fraternity issue and a new president, J. H. Smart, took office.

A second man, Henry L. Osborn, was appointed in 1884 as Instructor in Zoology thus aiding Professor Barnes in carrying on the instruction in "Natural History." The following year Professor Barnes was "out on leave" and the work in botany was carried on by an assistant, Elizabeth Shoemaker. A one-term (12 weeks) botany course was offered to freshmen and 16 weeks of botany offered to sophomores. Twenty weeks of zoology was offered to sophomores and 16 weeks of zoology to seniors. Additional work in both botany and zoology could be elected by juniors and seniors.

Professor Barnes left Purdue University in 1887 and was succeeded by Joseph C. Arthur who came as Professor of Botany, but shortly became Professor of Vegetable Physiology and Pathology. A second newcomer the same year was Stanley Coulter, Professor of Zoology, later Professor of Biology. Professor Coulter taught botany and zoology to freshmen and sophomores, and zoology to juniors and seniors. Professor Arthur taught vegetable histology and physiology to upper classmen. Graduate work for the M.S. degree was offered by both professors.

Thus "The Purdue Register" for 1888-90 (4) under the heading of post graduate courses in biology states: "One or more topics will be assigned as subjects for original investigation, in which it will be necessary to determine the structure, development of life history of some plant or animal, or trace the explanation of some phenomenon of growth, together with the history of the subject as treated by other investigators. A knowledge of French and German will be specially serviceable in this course."

"The general study of some department of biology will be required in addition to the above."

About this time Professor Coulter became secretary of the faculty. In 1890 D. T. McDougal joined the department as graduate assistant and later became assistant instructor. Eventually McDougal was awarded the Ph.D., the department's first and Purdue's second (5) for the thesis "Curvature of Roots" published in 1897 (6).

A general biology course taught by Professor Coulter was introduced in 1894. Shortly after, a course in bacteriology and one in fungi and fungus diseases were initiated by Professor Arthur.

The catalogue description for the course in bacteriology is as follows (7): "Bacteriology-Twelve weeks. The general morphology and classification of the bacteria, their development and most important biological relations are studied. The laboratory work includes the general methods of research, and also such special forms of investigation, i.e., the biological analysis of water, etc., as members of the class may desire. Professor Arthur."

Instructor Katherine Golden and Severance Burrage helped in these and in other courses within the department. Later other courses

were added including Fermentation (Golden), Plant Ecology (Arthur) and Biology of Water Supplies (Burrage).

Catalogue descriptions for the additional bacteriology courses read as follows (7): "Biology 6: Fermentation. Twenty-three weeks, eight hours per week. Preliminary study of yeasts, molds and bacteria leading to the morphological and physiological study of organisms found in bread, beer, cider, molding fruits, milk, prepared foods on the market, etc. The work is of a practical nature, and is designed to give a student a working knowledge of the problems affecting foods. Jorgensen's Micro-Organisms of Fermentation is used in connection with other standard works, as text. Instructor Golden."

Also we find (7): "Biology 11: Bacteriology: Thirty-seven weeks, eight hours per week. A general course, utilizing the modern methods of culture for the study of bacteria, and bearing particularly upon the bacteriological examination of water, sewage, ice, air, soil, milk, butter, etc., and the application of such results in the solution of modern sanitary problems. The members of the class make reports once a week on current articles bearing on this subject that appear in scientific periodicals. Instructor Burrage."

Still other courses were organized including Pharmaceutical Botany, Microscopic Technique, Commercial Timbers (at the behest of Civil Engineering), and Animal Physiology.

President Smart died in 1900 and was succeeded by Professor W. E. Stone, Head of Chemistry. In 1902 the previous three-term system was replaced by the present two-semester system.

Within the period of 1904-13 numerous new courses were added including Preventative Medicine, Industrial Biology, Comparative Morphology of Vertebrates, Mammalian Anatomy and Experimental Physiology. In addition, a whole new area (forestry) was developed within the department involving courses in forest botany, silviculture, mensuration, management, history, utilization, etc. Most of these courses were taught by Professor Coulter. During this period Dr. H. E. Enders and O. P. Terry (MD) were added to the departmental faculty. In 1909 Professor Coulter became Dean of Science and Dr. Enders took charge of the general biology course in addition to other courses which he taught. Dr. Terry served as university physician and in addition instituted courses in Human Pathology, Physiology and Hygiene, and Pharmacology. In the latter part of this period men joining the departmental staff included G. N. Hoffer (who taught plant physiology), C. M. Hilliard (microbiology) and P. A. Tetrault (bacteriology).

Early in the decade of 1914-23 C. A. Behrens (bacteriology), B. Prentice (forestry), C. M. James (physiology), and E. J. Kohl joined the staff. Professor Arthur left the Department to devote full time to his duties as botanist in the Experiment Station. The Purdue Catalogue for 1916-17 (8) lists a biology staff of 15 with Professor Coulter in charge. Professor Coulter was also in charge of Forestry, which was now listed separately. Thirty courses were offered in Biology, some of which were year-long courses. New courses added in this period included Sero-Reactions and Vaccine Therapy, Soil Bacteriology, His-

tology of Medicine Plants, and Parasitology. I. L. Baldwin, who later became a Department Head and Vice President of the University of Wisconsin. L. F. Heimlich, and C. L. Porter also joined the staff during this decade. In 1921 President Stone was killed in a mountain climbing accident and Journal and Courier publisher and University trustee Henry Marshall served as acting president along with Professor Coulter who handled academic affairs until 1922 when E. C. Elliott became president. At about this time Dean Coulter also became Dean of Men and Chairman of the Faculty. He relinquished active teaching duties, but continued as Head of the Department. Dean Coulter's qualities are summarized by Hepburn and Sears (3) as having: "an extraordinary personal prestige, an unequalled popularity among the alumni, and a consecration to the past, the present, and the future of Purdue."

The University Catalogue published in 1924 (8) for the first time segregates courses into those primarily for undergraduates (17 courses within the Department), for both undergraduates and graduate students (11 courses), and those primarily for graduate students (5 courses). During the decade of 1924-33 several seminars and problem courses were included in the new courses introduced. Dean Coulter retired in 1926 and was succeeded as department head by Professor Enders. New persons added to the faculty during this period included R. E. Girton (plant physiology), W. A. Hiestand (animal physiology), R. Greenwood (zoology), and F. Willis (bacteriology). Mr. Willis later joined the Purdue Health Service and subsequently served for some time as mayor of West Lafayette.

Following the death of the then Dean of Science (Dean Moore), Professor Enders became Acting Dean of Science in 1931. His appointment was made "permanent" in 1932.

During the final period under our consideration (1934-47) new members added to the biology staff included C. H. Alvey (parasitology), W. E. Martin (physiology), R. Cable (parasitology), W. H. Headlee (zoology), S. E. Hartsell (bacteriology), Elizabeth Mackay (botany), A. A. Lindsey (ecology), R. E. Wean (plant pathology and physiology), and W. R. Mullison (biology and plant physiology). Also during this period a new "Experimental curriculum for Women" was set up which included a Survey Course in Biology (Mullison). Additional new courses were added including seminars in animal physiology and plant physiology as well as some new courses in problems, techniques, and applied biology designated as "service courses." The period contained the World War II years when both the student body and the staff were considerably reduced in numbers. In fact some senior staff members were asked to serve part time as laboratory assistants in some of the larger introductory courses.

In 1946 Dean Enders went on terminal leave. Professor Tetrault was appointed as acting Head of the Department. New staff members coming at or shortly before this time were T. S. Hall (curriculum for women), C. Goodnight (animal ecology), and H. Koffler (bacteriology). Professor Hall later became a Dean at Washington University (St. Louis) and Professor Koffler the Head of Purdue's Department of Biological Sciences, following John S. Karling in that post. At this time there

were 22 courses listed as for undergraduates, 35 undergraduate-graduate courses, and 21 courses primarily for graduate students. Many of these courses were full year courses.

In conclusion attention is called to the very considerable growth of the Biology Department at Purdue under but four Heads from a one-man activity (Professor Hussey) to a numerous departmental faculty. Over the years the number and character of the subjects taught obviously changed to correspond with the growth of and demands made upon the department. Many new courses were added and older ones modified to meet the requirements of a steadily growing university. The current fourth quarter of Purdue's first century is finding tremendous growth and promise in the Department of Biological Sciences as well, of course, as in the entire University.

Literature Cited

1. The Purdue University Register. 1874-75. Lafayette, Indiana.
2. The Annual Circular of Purdue University. 1875-76. Indianapolis, Indiana.
3. Hepburn, W. M. and L. M. Sears. 1925. Purdue University. Fifty Years of Progress. The Hollenbeck Press. Indianapolis, Indiana.
4. The Annual Register of Purdue University. 1880-90. Indianapolis, Indiana.
5. Girton, R. E. 1958. The Teaching of Plant Physiology at Purdue in the Nineteenth Century. Proc. Ind. Acad. Sci. **67**:260-264.
6. MacDougal, D. T. 1897. The Curvature of Roots. Bot. Gaz. **23**:307-367.
7. Tetrault, P. A. 1944. History of Bacteriology at Purdue University. Proc. Ind. Acad. Sci. **53**:66-71.
8. The Annual Catalogue of Purdue University. 1916-26. Lafayette, Indiana.

Charles Redway Dryer

BENJAMIN MOULTON, Indiana State University

Early in the Spring of 1927 a group of properly dressed people could have been seen visiting a number of viewpoints and park sites in Ft. Wayne. They were not a particularly gay group for these visits were in memory of Charles Redway Dryer, whose funeral had been earlier in the day. This group consisted of his family and one former student.[1] The places visited were those that Dryer enjoyed most around Fort Wayne in the some 30 years he had lived in the city. Only in his native home area of central New York had he spent almost as much time. His third area of occupancy was at Terre Haute from 1893-1913.

The closing scene left little indication of the impact of this man upon the field of geography or the science of geography on the mind of this man. It is the purpose of these comments subsequently to review the contribution of Dr. Dryer to the field.

Charles Dryer was born in 1850 in the Finger Lakes district of New York in the village of Victor. This was and still is considered a scenic landscape, a product of the dissected Allegheny Plateau and subsequent glacial erosion. The area in which he was nurtured was occupied largely by people of English origin of which he was a prototype. Life was rigidly controlled. Education in the classroom was stereotyped in harmony with strict rules of no talking, no playing, no sleeping and in addition no drawing and no map making. However, with an early interest in landscape, maps held a fascination for Dryer and he states a teacher "connived" with him and let him draw maps in his spare moments in school.

Sent off to nearby Hamilton College, he graduated in 1871. Five years later he earned the M.D. degree at the University of Buffalo. From the literature, comments, type of writing, and area of studies; an impression of a rigidity of performance was part and parcel to the completion of this medical work. The work started must be completed and a dedication to that end was inevitable. Personal interest or feelings were of little authority in the work chosen. Interlaced with his work toward the medical degree, he taught school at Phelps Union and Classical School at Phelps, New York.

However, the practice of medicine was not to be long. Schockel claims Dryer was unsuccessful in the profession because of his straightforward treatment of patients. He had no sympathy or time for psychosomatics. Whatever brought his change, he started to teach at Fort Wayne in 1877, a year after receiving the M. D. degree. For several years his teaching was in the high school at Fort Wayne and in the Fort Wayne College of Medicine. His work at the high school was in Science, but his work at the medical school was in chemistry and toxicology. In the decade from graduation in 1876 his interest in land-

[1]The author is indebted for the use of many ideas and facts from a former student of Dr. Dryer, namely, Dr. Bernard Schockel. Also another student, Professor Emeritus Raymond J. Reece.

forms increased. He met many of the early geologists and in particular Frank Taylor of the U. S. Geological Survey. His first evidence of skill in physiography was publication in 1886 of a paper on the Wabash Valley in the Proceedings of the Indiana Academy of Science. Unlike so many of our earlier contributors to our earth science field, he had not come as a converted naturalist. He had only transferred the system of the laboratory to the landscape and evaluated there on. He was impressed with the work of Taylor.[2] By the time he had arrived to head the Department at the Indiana State Normal, he had published seven or eight papers on geologic features of the state. These papers in substance were on singular features or a group of closely related features that made up a facet of the geologic landscape. His published material was systematic and scientific.

He became acquainted with the staff in geography at Chicago, and had devoted some of his summer time to the Indiana Geological Survey under S. S. Gorby and others. His status was as an assistant in the Survey. He wrote the Pleistocene history of six N. E. Indiana counties.

In addition to the part-time work with the Survey, he also is listed as being a consultant with the Ft. Wayne Electric Company for three years prior to coming to Terre Haute.[3] Before his arrival at Terre Haute, then, in the period of 1890-93, he was simultaneously a member of the staff at the Fort Wayne Medical School, a consulting chemist, and an assistant in the Geological Survey. In this same period he is listed as being author of a number of papers.

In the fall of 1893 he joined the staff at Indiana State Normal School as a professor of Geography and Chairman of the Department. For the next eight school years the curriculum offered to the students consisted of physiography, meteorology, and political geography. Although he appears to have been the only instructor in his first year at Normal, thereafter one, two, or three members were associated with him. The source of the associates in his department were generally men not formally trained, but with a good education and an interest in geography. In 1897, as an example, he had added to the Department, Wm. A. McBeth. Professor McBeth was classically trained, but his excellent teaching ability and great interest in geography impressed Dryer. Also at the time, there were relatively few formally trained geographers available. Before the first ten years of his stay at Terre Haute, student assistants were listed as staff personnel. Among these Breeze, Schockel, and Tillman would move on to become better known.

One major break came in the curriculum offerings to students in 1905. For the first time a regional course in Europe appeared and a course in Methods of Teaching Geography.

Two factors may have been the cause of the curriculum changes. For several years after joining the staff at Normal, Dryer, to satisfy his needs and interests and perhaps as half defender and half missionary, wrote and prepared publications representing outlines of his

[2]He apparently also knew Frank Leverett and in 1908 Leverett spent several days with Dryer on the campus at Terre Haute.

[3]The information is conflicting. Some sources state he served as a chemist for the company. He probably was a full time employee since he no longer taught in the high school.

program, as for example the *Lessons In Physical Geography or Syllabi of Geography.* Also as vice-president of the Indiana College Association in 1897, he presented a paper, later published, entitled *Geography as a University Study.*

A second major situation developed during the academic year 1904-05 when he served as visiting staff member at Oxford under the influence of MacKinder and Herbertson.

Although MacKinder may now be the more famous of the two, Herbertson impressed Dryer most. Regionalism as proposed by Herbertson and perhaps the "humanization" of geography appeared reasonable to Dryer. At least, from 1905 on, many courses were added and in 1910 course offerings were about doubled. Geology was installed as a course but also was World Geography. Geography of North America, Economic Geography, and Social and Historical Geography. Enrollment jumped considerably as this distinguished scholar, who had lectured at Oxford, was sought out by students.

A turning point in type of publications also appeared. They involved studies of:

1. A Western New York Farm 1911
2. Glacial Economics and Sociology 1911
3. Maumee—Wabash Waterway 1919
4. Economic Region of U. S.—1915
5. Genetic Geography—1920

A high school text published in 1911 was quite successful. Good reviews occurred and to a man, sixty-one at the time, a good financial reward appeared.

In 1913, he resigned his position at Normal to return to Ft. Wayne and to writing additional texts. Major contribution to the profession of geography appeared in the presidential address of the Association of American Geographers (Genetic Geography) for 1919. This certainly pleaded for order in geographic thinking; and for an ecological approach to geography. In 1924, he prepared "A Century of Geographic Education in the United States."

He prepared two additional manuscripts for texts. One was on North America and the other on Indiana. World War I seriously interrupted plans, subsequent modifications, interruptions, and death finally left these manuscripts behind.

At a time when seventy was the respectable retirement age, Dryer had retired at sixty-three. To many it seemed premature and a surprise. Schockel gives these reasons for retirement.

1. Terre Haute, rowdy, vigorous, dirty, smelly never appealed to Dryer or his wife.
2. Generally felt students were not of quality.
3. Felt income from publications would support him.

Dryer the Man

Dryer married in 1874 a girl of English ancestry. They had four children, one boy and three girls. The best known was the oldest, who

became a commercial chemist in Cleveland. Mrs. Dryer, no doubt, had considerable influence on the professional life. Home was the proper, mannerly, orderly place. Dryer was dressed in the style of the times and the proper clothes for Sunday were also his clothes for every other day and including field work.

Schockel particularly, and Reece remark on the scholarly qualities of the man combined with his classical education. He could with ease teach Latin, Chemistry, Geography, and English. Reece particularly comments on the ability of Dryer to discuss Shakespeare. Schockel states most students held him in varying degrees of awe, fear, reverence, and amazement. His teaching demanded preparation by students before class time. Questions would pass from student to student around the classroom. A correct answer brought praise or encouragement. A wrong answer brought the blunt answer "You're wrong." Classes were formal and rigid.

Some of the teaching systems were continental in character. Under Dryer's influence great relief models were acquired. His favorite technique was to assign students to study them until about any question Dryer asked about the region represented by the model would be answered.

Field work was important. Dryer never owned a car. Transportation was by Interurban for several miles away and then great hikes. Often a month's field trip with six or eight students. A bicycle was another transportation device.

Contemporaries were Davis, Johnson, Ridgey, Buzzard Tower, Salisbury, Barrow, Atwood and others.

The Conclusion

Studies such as these reflect a number of adverse conditions including:

1. Interpretation of the memory of students.
2. The lack of material preserved about the individual by institution or family.
3. The lack of the individual recognizing their importance and thus fail to keep a journal.

In trying to equate these the author believes that Dryer:

1. Increased his own personal happiness by studying geography.
2. For twenty years vastly improved the stature of geography at Indiana Normal.
3. Made fundamental contributions to geographic information for Indiana.
4. Made national contributions through publication.
5. Materially and educationally contributed to the Association of of American Geography by repeated publications and serving as President in 1919.

In Dryer, for the age and time, Indiana Normal had one of the great geographers of the day. His work and contacts reveal that stature.[4]

[4]A short bibliography of his published materials may be found in the Necrology report of the Proceedings of the Indiana Academy of Science, Vol. 37, 1927, pp. 33-34.

MATHEMATICS (No Papers)

PSYCHOLOGY (No Papers)

PHYSICS

Chairman: KONSTANTIN KOLITSCHEW, Indiana Central College

H. K. HUGHES, Indiana State College was elected chairman for 1965

Fourier Synthesizer

DAVID H. ALMAN[1] and HAROLD K. HUGHES, Indiana State University

Fourier series, from Fourier's theorem that any periodic function may be represented as an infinite sum of sinusoidal terms, are useful in many fields of science. It is desirable, therefore, to have a practical teaching aid and an industrial research tool in the form of a Fourier series synthesizer.

Industrial research can utilize a synthesizer in such fields as electronic circuit design, medical research, radar design, and vibration analysis and correction. A leading tire manufacturer, for instance, eliminated the harsh noise from one of its models by designing it so that the audio frequency noise from the tire hitting the pavement blended in with the background noise.

For classroom use and in many industrial applications, a synthesizer should be simple to operate, accurate, inexpensive, and its output should be easy to display.

Heretofore, only specialized synthesizers have been built. Lord Kelvin in 1872 built a successful tide predictor based on harmonics whose periods and phases were deduced from past records, For each harmonic he used a Scotch yoke, shown in Fig. 1. This is a device for changing rotary into linear motion.

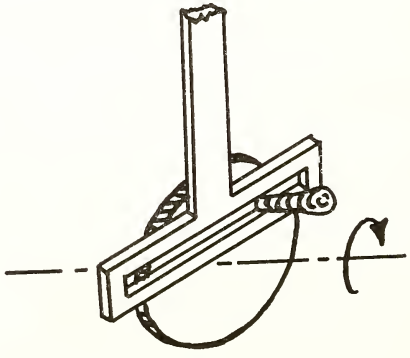


Figure 1. Scotch yoke.

One of these Scotch yokes was used for each component and the various tidal constituents (due to the moon, sun, etc.) were summed by a rope passing over pulleys connected to the ends of the Scotch yoke bars. The resultant curve was drawn on a revolving drum.

[1]Present address: Physics Department, Indiana University, Bloomington, Indiana.

Electrical Methods of Synthesis

Kelvin's synthesizer and several like it are for specific purposes only and are too bulky for classroom use. It is desirable, therefore, to have a smaller synthesizer, yet one which gives an electrical output with at least the first ten harmonics. An electrical output makes it convenient to display the resultant waveform on an oscilloscope.

Two of the methods of synthesis investigated in this study are: (1) a rotating parallel plate capacitor and (2) a rotating dielectric between the parallel plates of a capacitor.

Rotating Plate Method

A Fourier series in the familiar form

$$F(x) = \tfrac{1}{2}\, a_0 + a_1 \cos(x) + a_2 \cos(2x) + a_3 \cos(3x) + \ldots \quad (1)$$
$$+ b_1 \sin(x) + b_2 \sin(2x) + b_3 \sin(3x) + \ldots$$

may be written as

$$F(x) = \tfrac{1}{2} a_0 + A_1 \sin(x + \phi_1) + A_2 \sin(2x + \phi_2) \tfrac{1}{2} \quad \ldots \quad (2)$$

where ϕ is a phase angle. The problem then is to obtain sine functions of integral multiple frequencies with adjustable phases and amplitudes. One method to solve this problem uses the relationship for the current to a parallel plate capacitor of variable area,

$$i = \frac{\varepsilon V}{D} \frac{dA}{dt}.$$

where ε is the permittivity, V is the applied voltage, A is the area and D is the plate separation (mks units). That is, the current is proportional to the time derivative of the plate area.

As shown in Fig. 2, a parallel plate capacitor is constructed such that the top plate is split into semi-circular halves. These halves are connected to a power source, one positive and the other negative with respect to ground. A parallel ground plate, rotated by a motor, is first under one and then the other split stationary plate. The rotating plate assumes a negative charge when it is under the positive plate and a positive charge when it is under the negative plate. It assumes some intermediate charge when it is under both halves.

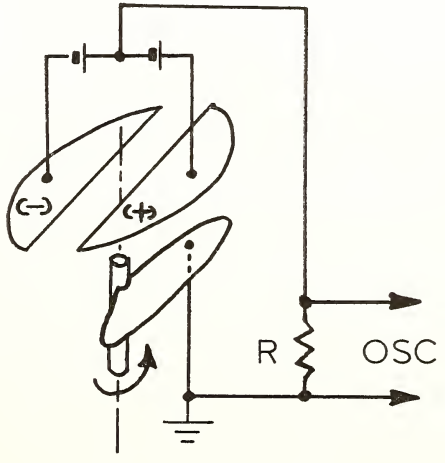


Figure 2. Split plate capacitor.

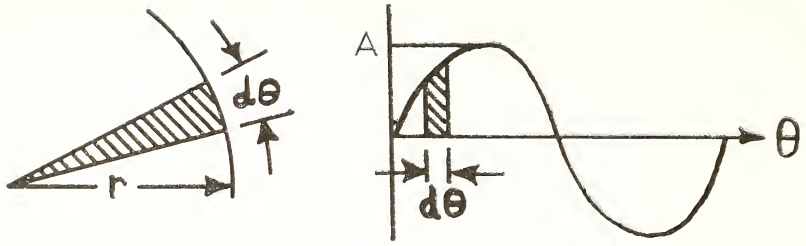


Figure 3. Equal areas.

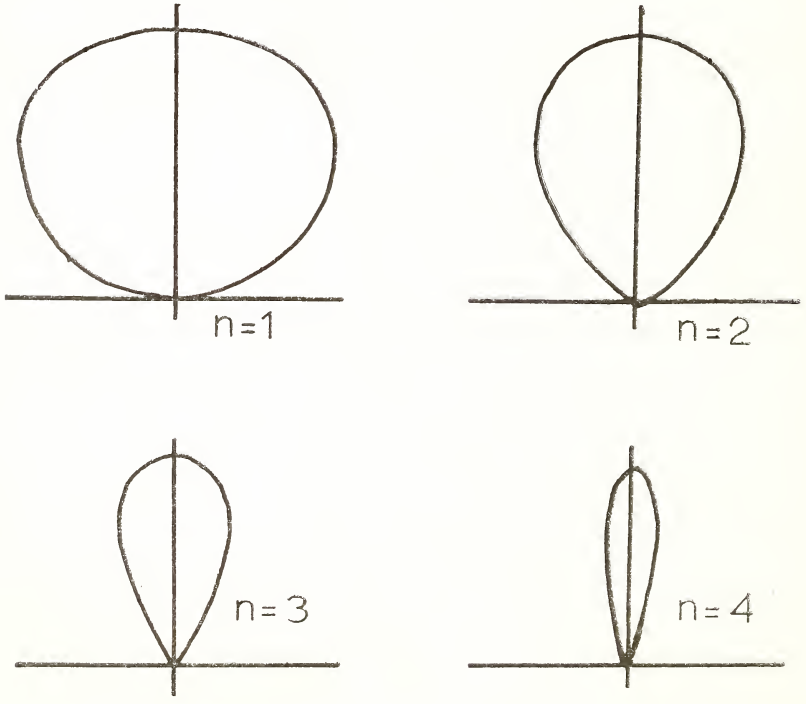


Figure 4. Base plate design.

The output signal developed across the resistor R is displayed on an oscilloscope. $\frac{dA}{dt}$ of eq (3) must be a sinusoidal function of time and so the common area between the rotating plate and one top half-plate must vary as a sine function.

The area of an infinitesimal sector in polar coordinates, as shown in Fig. 3, is proportional to $r^2\, d\theta$, and the area of an infinitesimal slice under a sine curve in cartesien coordinates is proportional to $\sin(\theta)\, d\theta$. Equating these two the shape of the rotating plate is described by the polar equation

$$r = \sqrt{2A \sin \theta} \qquad (4)$$

The shape looks somewhat like a heart for the fundamental. See Fig. 4. For higher harmonics, the radius is proportional to the square root of the sine of $n\theta$ where n is the harmonic number and θ is the angle of rotation. It is seen in Fig. 4 that for harmonics above the fourth, the rotating plate is difficult to make.

To obtain the 2nd, 3rd, etc., harmonics, the top plate is split into 2n equal pie-shaped sectors, where n is the harmonic number. Alternate sectors are connected together; the two leads go to the plus and minus supply voltage. For a synthesizer with several harmonics, the rotating plates are fastened to a common shaft; therefore, there is a reference point for the phase angles, and the output frequencies are exact multiples of the fundamental.

To obtain a variable phase angle of the Fourier series of eq (2), the top split plates are fastened to insulators such as plexiglass, which are rotated through 360 degrees.

An experimental model employing this method was constructed for one harmonic. It gave an output very much like a sine wave. Extensive shielding was required to filter out stray capacitance and electrical noise.

Rotating Dielectric Method

Another method of generating sinusoidal functions uses a thin sheet of dielectric of the same shape as the previous method, i.e., $r \propto \sqrt{\sin(n\theta)}$. This sheet is rotated between stationary parallel plates. The dielectric increases the capacitance by a factor ϵ_r, causing the capacitance to change as a sinusoid; thus, the current through resistor R varies as a sine function.

To obtain many harmonics with adjustable phase angles, several pieces of the dielectric are connected to the same rotating shaft. The split plates may be rotated through 360° for phase control as described earlier.

Discussion

These capacitor methods were discarded in favor of a photoelectric tube method for several reasons. The precision and shielding required of the former are excessive, to name just two. The phototube method will be reported elsewhere.

Using these capacitor methods, or the better phototube method, an inexpensive, compact, and accurate synthesizer may be constructed for use in the classroom or industrial laboratory.

A Constant Speed Drive for Mossbauer Experiments

CHARLES F. HACKETT and HAROLD K. HUGHES, Indiana State University

In recent years, there has been much interest in recoilless emission and absorption of low-energy gamma rays. When a free nucleus of mass m emits a gamma of energy W_g, the nucleus recoils with an energy W_r which is approximately equal to

$$W_r = \frac{1}{2m}\left(\frac{W_g}{c}\right)^2 \qquad (1)$$

where c is the speed of light. For the 14.4 kev gamma from Fe^{57} shown in Fig. 1, this energy is about 0.002 ev corresponding to a speed of 82 meters/sec.

It might seem that the recoil energy and speed are insignificant until it is realized that the "natural" or Heisenberg line width is only about $\Gamma = \frac{h/2\pi}{\Delta t} = (6.60)10^{-16}\ (10^7/1.4) = (4.7)10^{-9}$ ev (2)

There will, thus, be no absorption if this same gamma falls upon another identical, but unexcited nucleus because the energy of the gamma ray is shifted off the absorption resonance curve.

The Mossbauer Effect

In 1958 Rudolph L. Mossbauer demonstrated that it is possible to bind a radiating nucleus to a solid so firmly that the recoil momentum is shared by the entire lattice rather than being concentrated in one atom. When this happens, the corresponding recoil energy of Fe^{57} is of the order of 10^{-19} ev, a shift so insignificant in comparison with the width of the nuclear energy level that now resonant absorption can take place.

Atoms bound in solids can absorb energy only in units of the phonon vibration energy. If the calculated recoil energy is less than the phonon energy, the radiated quantum carries away the full energy in many emissions and there is no recoil.

Constant Speed Drive

In order to sweep out a resonance curve and to perform other interesting Mossbauer experiments in nuclear and solid state physics, a very constant speed drive is needed. Some experimenters employ a lathe. We have chosen to follow the basic design of A. J. Bearden, who rotates a stainless steel foil at such an angle to the gamma ray path that there is a longtitudinal component for Doppler shifting the resonance curve. Both the angle and the speed of rotation are adjustable in our modification shown schematically in Fig. 2.

A sheet of 1-mil stainless steel absorber is sandwiched between two plastic disks mounted on a freely rotating shaft. The source material Co_{57} and phototube are mounted on a bar. The velocity component of the absorber, relative to the source, can be adjusted by pivoting the bar. The velocity component can also be changed by varying the speed of the wheel.

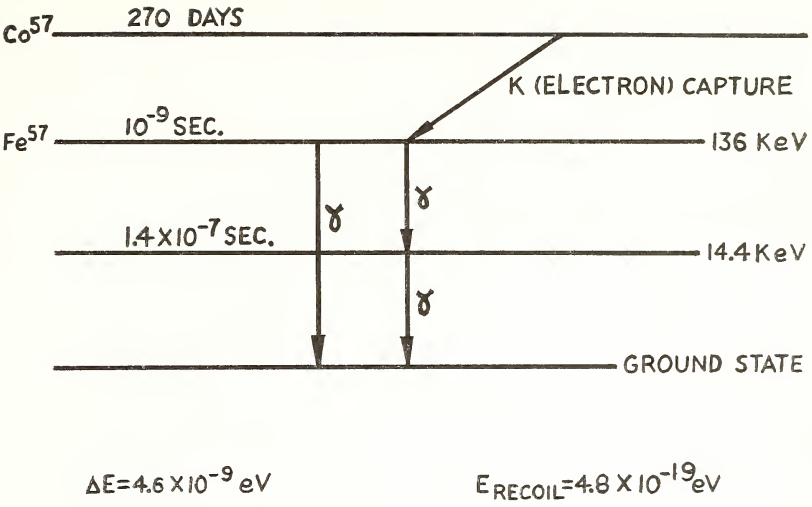


Figure 1. Decay of Co^{57}.

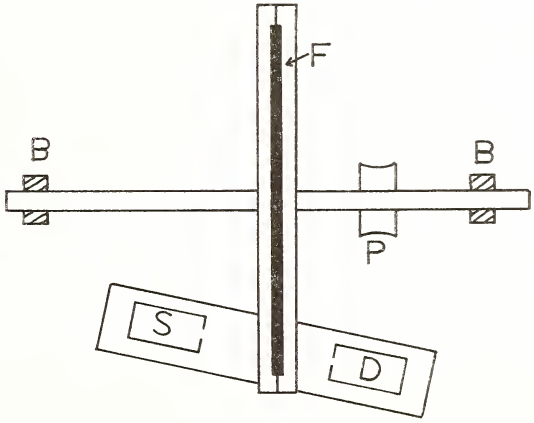


Figure 2. Top schematic of wheel, showing the shaft held in bearings B, sources and photomultiplier detector D on pivoted bar, stainless steel foil F held between two plastic discs, and o-ring drive pulley P.

The wheel is driven by a Servo-Tek dc motor using an o-ring and pulley. This motor, geared down to 18 rev/min maximum output speed, operates with 100 volts on the field winding and a maximum of 2.0 amperes through the armature. The armature requires 55 volts at full speed. Coupled directly to the motor is a generator tachometer whose voltage is directly proportional to the motor speed. This speed is linear with armature current in the range 1.3 to 2.0 amperes. In order to control the motor speed, thus, one must control the armature current.

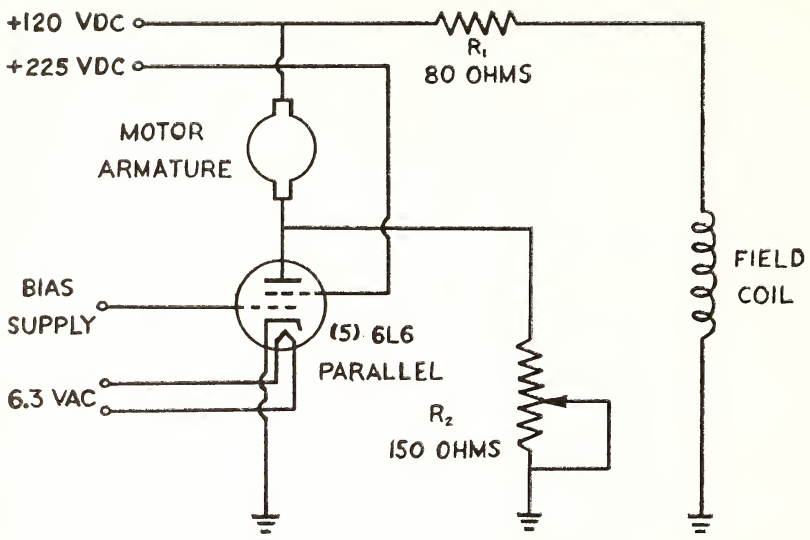


Figure 3. Connections to motor.

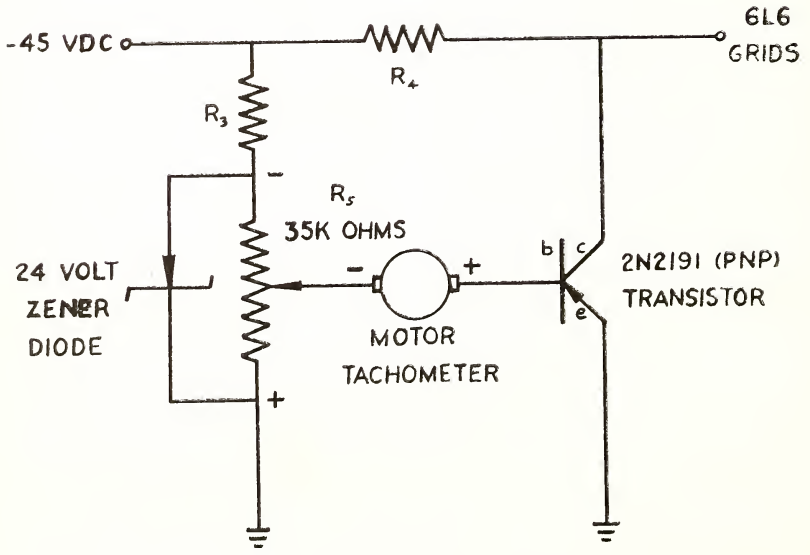


Figure 4. Transistor amplifier and feedback.

Motor Control Circuit

The total voltage across the armature and tubes in Fig. 3 is 120 while across the field winding is 100 volts. The current through the armature divides; 1.3 amperes is carried by a large rheostat R_2 and the remainder of the current is carried by the five 6L6's in parallel. By

controlling the grid bias of the 6L6's the current through the tubes, and therefore the motor speed can be controlled.

The motor tachometer generates 1.3 volts per rev/min of the output shaft. This tachometer voltage is compared to a stable reference voltage supplied by a 24-volt zener diode in parallel with a 35 k-ohm potentiometer, as shown in Fig. 4. Their difference is fed to a PNP transistor. After amplification the difference voltage is coupled to the grids of the 6L6's.

In operation, an increase in speed of the motor increases the tachometer voltage. This provides a less negative voltage of the transistor base relative to the emitter, which in turn causes more current to flow through the transistor. Thus, the control grids of the 6L6's are driven more negative, which reduces the current through the tubes and decreases the motor speed.

Operation of the Circuit

To start the motor, the reference voltage is set to zero so that 6L6's are operating at maximum bias. This limits the current in the tubes to a safe value. The large rheostat R_2 coarse speed control is then set to a value such that the motor just begins to run—about 1.3 amperes through it. Next, the potentiometer across the zener diode is set so that the 6L6 grid bias is minus 15 volts. This adjustment is the fine speed control.

Because of the feed-back system being used, the fine speed control must be adjusted several times, until the grid bias remains constant at about minus 15 volts. Once this operating condition is reached the motor will run at a constant speed, compensating for circuit element heating or line voltage variations.

One of the tests performed on the motor control was as follows: a resistor and switch were placed in the 120 volt input to the armature. While operating the motor, the resistor was switched into the circuit. This dropped the input voltage by 12% but the motor speed decreased by only 3% and very quickly returned to its original value.

Energy Ether

JOHN F. HOULIHAN, DePauw University

I come before you this morning not with the usual type presentation, for I have no experimental data nor any sophisticated mathematical formulations to present. I come only with a simple idea. In fact, the thought I wish to discuss with you this morning is but the fetal skeleton of a concept that I hope to bring to maturity, even as I myself approach intellectual maturity.

At an Indiana Central College Faculty Discussion in January of 1958, Dr. Konstantin Kolitschew, Chairman of the Physics Department at Indiana Central College presented a paper entitled "Boundary of the Unknown." In this discussion he presented a Time Energy Aggregate or Manifoldness made up of a mixture of free quanta and time.

A little over three years ago I had the opportunity to read this paper, and it is from this discussion that the energy ether hypothesis stems.

Since I first began to consider the energy ether concept you are about to hear, it has undergone the evolutionary process of re-evaluation and reconsideration in almost every aspect. It is quite probable that it will be subjected to an even more critical analysis in the future.

According to Auguste Comte man passes through three phases of history as he begins to uncover the secrets of Nature; the Theological phase, the Metaphysical phase and the Scientific phase. In the theological phase, men attempt to explain the natural phenomena they do not understand by gods or supernatural forces. In the metaphysical phase they are explained by "abstract" forces, that is by those forces that may not be observed. An example is Newton's "action at a distance" which he introduced in his discussion of the nature of gravity. Finally, in the scientific phase, these same natural phenomena are explained in terms of those things which may be directly or indirectly observed. The method of this final phase is in essence, of course, the scientific method.

Without totally disregarding the possibility of some complementary telelogical explanation, it appears to me that the scientist must attempt to view all aspects of natural phenomena in accordance with the scientific method if he hopes to maintain his intellectual integrity. This has been accomplished to a very great extent by modern science; however, the concept of "empty space" has yet to be considered in anything more advanced than a metaphysical mode of thought.

When Albert Einstein introduced his special theory of relativity he did not define what he meant when he referred to a space-time continuum, he simply postulated that this entity had certain properties. Among them he included the ability to propagate electromagnetic radiation. Just recently in the meter-kilogram-seconds-ampere rationalized system of units, empty space was assigned two properties, mag-

netic permeability and electric permittivity, which are related by the expression:

$$C = \frac{1}{\sqrt{\varepsilon_0 \gamma_0}}$$

If we simply accept that space has these properties, and indeed electromagnetic radiation is propagated, life is very simple for the man of physics. However, if we attempt to understand how this medium supports electric and magnetic fields, we are led to some interesting conclusions.

The following hypothesis is an attempt to analyze this entity, empty space, in a more realistic manner and put our knowledge concerning it on a more stable foundation.

Energy may be transmitted only by the motion of particles or waves, and as DeBroglie and Bohr have pointed out these are essentially the same; all particles having a wave characteristic and all waves having a particle characteristic. These two are related by DeBroglie's equation $mv = \frac{h}{\lambda}$. For wave motion to be transmitted by a medium it is necessary that the medium be elastic, (i. e. have a discrete structure). The question is then raised what constitutes these discrete particles in the Space-time continuum, and then, what is between the discrete particles.

It was in answer to this question that Kolitschew suggested that the mysterious entity "space" be replaced by the well-known entity energy, which may not only be discrete and elastic, but may also be a true continuum. This energy-time continuum which accounts for everything the Einstein postulated space-time continuum included, I have chosen to call energy ether.

A cursory glance at the following presentation would lead the observer to believe that this is a return to the all-pervasive ether originated by Rene Descartes early in the 17th Century. This however, is not the case. The ether of which I speak, is like Descarte's ether, a hypothetical "substance" filling the universe, inclusive of those volumes occupied by ordinary matter and serving to transmit all electromagnetic radiation. This ether, however, is of an energy nature, and does not consist of matter as did Descartes'.

As stated by the laws of thermodynamics, all processes naturally produce heat, and this heat diffuses, tending to equalize the temperature of our entire universal system. All energy processes terminate as heat energy and we might therefore say that heat energy is the "ground state" of energy. After these processes have reached the ground state the "latent" heat energy diffuses throughout the universe.

It follows from the principles of quantum theory that all energy is emitted and absorbed only in multiples of a definite small amount, the quantum. This suggests that the "latent" heat which diffuses throughout the universe does so as quantum or bundles of energy. These bundles of energy naturally seek their lowest energy level (again according to the laws of thermodynamics), and find it as individual

quanta, or as the lowest possible multiple of the before mentioned definite small amount.

The numerical value of this elemental unit of energy is given by Plank's constant, and the energetic mass of it may be calculated by reversing Einstein's equation for the transformation of matter into energy. It is found to be 7.36×10^{-48} grams.

$$E = mc^2$$

$$6.62 \times 10^{-34} \text{ joule} = m(3 \times 10^8 \text{ m/sec})^2$$

$$\frac{6.62 \times 10^{-34}}{(3.\times 10^8)^2} = m$$

$$7.36 \times 10^{-48} = m$$

The latent heat quanta with such an energetic mass, form the energy ether.

While I have been referring to the ether as being composed of latent heat energy, I do not wish to project an image of a static ether. In fact, because the quantum is inherently an energetic entity, the ether would be of necessity a dynamic medium. We must further assume the individual quanta which compose the ether are in random motion; otherwise we would be able to detect a sizeable fringe shift in experiments similar to the Michaelson-Moreley experiment.

If the quanta are in random motion the velocity of propagation of the electromagnetic radiation through this medum would be the root-mean-square velocity of the components of the medium. We are therefore able to determine the velocity of these component quanta quite simply by choosing a distribution function of $\frac{dn}{dv} = KNV$

$$\bar{V}^2 = \frac{\int_0^{vmax} \frac{v^2 dn}{dv} \, dr}{\int_0^{vmax} \frac{dn}{dv} \, dv} = \frac{\int_0^N r^2 dn}{\int_0^N dn} =$$

$$\frac{\int_0^{vmax} (KNV) V^2 dv}{\int_0^{vmax} (KNV) dv} = \frac{KN \int_0^{vmax} v^3 dv}{KN \int_0^{vmax} vdv} = \frac{\frac{V^4}{4}}{\frac{V^2}{2}} =$$

$$\frac{V^2 m}{2}, \quad \frac{Vm}{\sqrt{2}} = .707 \, Vm = \sqrt{\bar{V}^2} \, C = \sqrt{\bar{V}^2}, \quad 7.36 \times 10^{-48} = m$$

$$\frac{C}{.707} = Vm = 4.24 \times 10^8 \text{ m/sec.}$$

That this velocity is well over that of light should not cause too much consternation, for although this seems to be a contradiction of Einstein's theory of relativity at first, it is on the contrary, a reasonable explanation of the presence of phase velocities greater than the speed of light which are encountered in the study of the transmission of electromagnetic radiation and also explains why no energy may be transmitted at a velocity greater than that of light.

Absolute zero is usually defined as the condition at which there is a complete absence of heat. We have just discussed the "latent" heat nature of energy ether and might therefore logically conclude that absolute zero would be the only condition at which there would be a complete absence of energy ether. With no ether present, we would not expect electromagnetic radiation to be propagated. Continuing our reasoning still further we find that energy ether hypothesis predicts that as the density or the energy level of the ether decreases (the temperature decreases) the intensity of electromagnetic radiation will decrease also. If we do not pursue the analogy too far we may find it helpful to consider the demonstration of the ringing bell which is placed under a bell jar. As the jar is evacuated the intensity of sound decreases proportionally.

The preceding paragraph may suggest one manner in which the energy ether hypothesis may be tested empirically. Namely, by measuring the intensity of a source of electromagnetic radiation as its surroundings are made to approach absolute zero. If the intensity is shown to decrease, the energy ether hypothesis will be supported.

Recently I have been doing a limited amount of research reading in low-temperature physics in an attempt to analyze this hypothesis further. The energy ether concept is consistent with much of the data and offers an explanation for a number of the observed phenomena.

It has ben observed that every metallic conductor opposes the passage of electrical charges through it. This opposition is due primarily to the collisions of the moving charges with the vibrating atoms in the crystal structure of solids. As the temperature decreases the resistance decreases correspondingly. If the random motion of the quanta cause atoms to vibrate due to a Browian type bombardment we can see that the energy ether concept is in agreement with this observed phenomenon.

If a permanent magnet is dropped into a dewar containing a lead plate immersed in liquid helium it will not fall to the plate. It will remain suspended some distance above the superconducting lead. This phenomenon, termed the "floating magnet effect," is explained by the fact that as the magnet nears the surface, electric currents are generated in the lead plate's surface and the resultant magnetic field just counter-balances the field of the magnet. However, if the strength of the magnet is increased it penetrates the plate and destroys the superconductivity. Postulating that a magnetic field is a standing wave in the ether one would expect just such a result, due to the interference between the standing waves and the atoms of the superconductor. It has been observed also that the lower the temperature the more magnetic force needed to destroy the superconductivity. This too, is predicted by the energy ether hypothesis.

It may well be asked what the importance of this hypothesis is to the field of physics. In a recent issue of Scientific American, Mr. P.A.M. Dirac, one of the foremost theoretical physicists of our day, discussed the impasse with which modern physics is confronted due to the extreme complexity and abstract mathematical nature of many of our

current theories. At one point he remarks, "There will have to be some entirely new development that is quite unexpected, that will take us still further along the road of knowledge." He later suggests three ideas he feels might lead to this new development. The first is to ". . . . introduce something corresponding to the luminiferous ether, which was so popular among the physicists of the 19th Century."

Whether any aspect or aspects of the energy ether hypothesis are correct or not is a question which must be answered in the future after more experimentation and study have been done, but it seems foolish to me that, an entity as potent in physical properties as this unknown aggregate is, should continue to be considered as "empty space" when the energy ether concept would allow us to consider it in a more scientific mode of thought. I feel that the historical term ether should be retained for this entity and its nature analyzed further.

PLANT TAXONOMY

Chairman: Robert Petty, Wabash College

Gayton C. Marks, Valparaiso University, was elected chairman for 1965

ABSTRACTS

Graphical analysis of the size-class structure of old-growth forests in Indiana. D. V. Schmelz and A. A. Lindsey, Purdue University—Density data for 23 stands were plotted on semi-logarithmic paper according to size-class distribution. No perfectly straight line, characteristic of a balanced distribution, was obtained. Four patterns of configuration were recognized and interpreted as indicating differences in amount of past disturbance and relative degrees of recovery. A straight line, fitted to the data by the method of least squares, was interpreted as representing the over-all condition of the stand at the time of study. The coefficient of determination was taken as an index of disturbance at the present. Estimates of the undisturbed condition were made by comparing various portions of the line connecting the plotted points with the regression line. Confirmation of these conclusions was obtained by the 1954-1964 tree-by-tree comparison of one of the stands.

Preliminary Studies on the Genus Polygonum, sect. Polygonum (Avicularia) in North America. Thomas R. Mertens, Ball State Teachers College.—Although the limits of *Polygonum* sect. *Polygonum* have been sharply defined on the basis of pollen morphology, there has been little agreement as to specific limits in North America. An attempt to resolve the complex referred to *P. aviculare* in North America necessitated an evaluation of the entire section of the genus. Using primarily fruit characteristics, *P. fowleri* could not be consistently distinguished from *P. allocarpum;* likewise, *P. raii* and *P. oxyspermum* were not separated by constant characteristics. Specimens identified as *P. exsertum* were referred to *P. ramosissimum* since the identity of the former entity appears to have been based on abnormal late-season fruits. Specimens referred to *P. fowleri* and collected in Marin Co., California, are unlike *P. fowleri* and will be described as a new species, *P. marinense* Mertens and Raven. The immediate *P. aviculare* complex seems to be represented in North America by two specis: *P. aviculare, sensu stricto* ($2n=60$) and *P. arenastrum* ($2n=40$). Although the distinction between these two is rather sharp in Britain, many North American collections referred to *P. arenastrum* on the basis of fruit size lacked the fruit shape characteristic of that species. Collections of *P. arenastrum* made in California and Indiana were confirmed by chromosome counts. *P. aviculare* collections from California were verified in the same manner.

Forest Analysis of a Mesic Ravine, Parke County, Indiana

ROBERT PETTY, Wabash College

Introduction

The specific effects of physiography upon forest composition, and more particularly the nature of exposure under which particular plant communities develop has been the subject of many phytosociological studies. In Indiana, such studies were reported by Friesner and Potzger (1) and Potzger (5) (6). Their studies dealt with the older physiographic sections of the state and demonstrated that north-facing slopes provide microenvironmental conditions which result in the development of forests whose composition is in marked contrast to those of south-facing slopes. Little or no data have been published concerning species expression on soils of contrasting exposure in narrower more mesic ravines. This paper reports a study of slope forest analysis in a relatively narrow east-west ravine in the Allee Memorial Woods.

Location and Description of the Area

The Allee Memorial Woods comprises 180 acres of partially virgin timber located in Parke County, one and three quarter miles west-northwest of the village of Annapolis on the east-south bank of Sugar Creek. This area was subjected to both Illinois and Wisconsin glaciation. Meltwater outwash of the latter and subsequent erosion left the terminal upland dissected by steep ravines which drain into Sugar Creek. The soil is underlain by a thin veneer of glacial drift supported by massive coarse-grained Pennsylvania sandstone of the Mansfield formation (7). Soil of the ravine sides has been classified as Hennepin, derived from a mixed parent material of drift and bedrock.

Site Analysis

The ravine itself is approximately 1000 feet in length. Its mouth empties into Sugar Creek. The upland discontinuity averages 100 feet with a mean gorge depth of 90 feet. The north-facing exposure is 92% slope and the south-facing exposure 80% slope. The ravine terminates in a "box-canyon" with face-walls to 50 feet. An intermittent tributary produces a waterfall at this point. Evaporation losses from the south-facing slope as measured by Livingston atmometers ranged from 30% higher near the mouth of the ravine where the width is approximately 160 feet to 10% lower on the south-facing slope in the narrow end. Jackson (3), working in this same ravine three years later found the higher figure to be 27%.

Midslope air temperatures recorded at one foot gave south-facing maxima which averagd 8 degrees higher (Jackson, 3 degrees higher) and minima one degree higher than the north-facing slope. Soil reaction of the north-facing slope averaged pH 6.6; for the south-facing slope, 5.0. Soil phosphate compared 41.9 ppm on north-facing slope, 7.5 ppm on south-facing slope. Potassium was found slightly higher on

the south-facing slope. The soil of the slopes is shallow sandy loam with little to no B-Horizon development.

Forest Tally

A full tally was made of both slopes in the summer of 1960 using a continuous grid of 1/40 acre quadrats. Forty quadrats were laid out on the north-facing slope; 29 on the south-facing slope. The latter number is smaller due to the presence of two lateral cuts in the north wall which are not a southern exposure. All individuals one inch or more *dbh* or 3 feet or more in height were tallied. Twenty-three tree species were identified on the north-facing slope which comprised a total of 577 stems. Of these, 107 were above 3 inches *dbh* giving a stand density of 107 trees per acre. On the south-facing slope 22 tree species were identified with a total of 463 stems. Of these, 104 were above 3 inches *dbh* giving a stand density for south-facing slope of 144 per acre. Reproduction as reflected in stem diameters below 3 inches gives a stand density of 496 for the south-facing slope; 470 for the north-facing slope. These data are presented in Tables 1 and 2, and Figure 1.

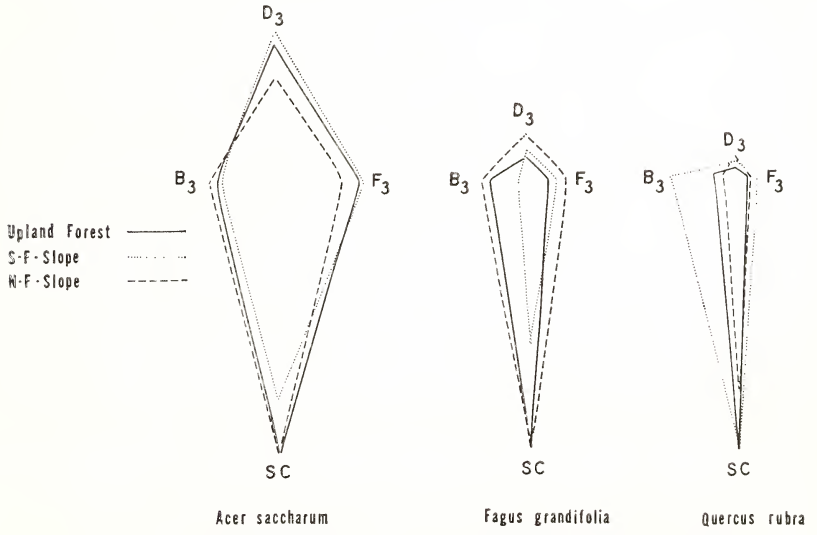


Figure 1. Phytograph polygons for three tree species on three site types.

The three dominant species on both slopes are sugar maple (*Acer saccharum*), beech (*Fagus grandifolia*), and red oak (*Quercus rubra*). Bitternut hickory (*Carya cordiformis*), *shagbark hickory* (*C. ovata*) and white ash (*Fraxinus americana*) were absent from the north-facing slope in the size classes above 3 in. d.b.h. Dogwood (*Cornus florida*) was not found on the south-facing slope. Variation in forest attributes of the slopes from the upland is shown in Table 3 and the phytographs in Figure 1. Symbols are after Lindsey (4): D_3 (relative density), F_3 (relative frequency), B_3 (relative basal area), V_3 (importance value) and SC (maximum size class). Nomenclature follows Gleason (2).

TABLE 1—Tree Species Composition of the North-Facing Slope Base on forty 1/40 acre plots.

	Diameter Size Classes									
	below one	1-2	3-4	5-9	10-14	15-19	20-25	26-30	above 30	total above 3″ dbh
Acer negundo	1									
A. rubrum	3				1					1
A. saccharum	220	49	13	13	7	4	2	1	1	41
Carpinus caroliniana	4	2	1							1
Carya cordiformis	13									
C. glabra	8		1	1						
C. ovalis					1					2
C. ovata	1									
Celtis occidentalis	37	2								1
Cornus florida	23	3	1							
C. racemosa	2									
Fagus grandifolia	18	3	6	4	4	2		2	1	19
Fraxinus americana	23									
Gymnocladus dioica	1									
Liriodendron tulipifera	3	1			1					1
Ostrya virginiana	7	4	1	4						5
Quercus alba			1		1		1		1	4
Q. rubra	2		1	1	2	3				7
Q. velutina	8			1			1			2
Sassafras albidum	2		1	2	4					7
Tsuga canadensis	10	1	1	2	2	3	3			11
Ulmus americana	19			1	1	1				3
U. rubra				1				1		2
Total	470									107

Stand Reprod. Density — 470/acre

Stand Density — 107/acre

TABLE 2—Tree Species Composition of the South-facing Slope

Based on twenty-nine 1/40 acre plots.

	Diameter Size Classes									
	below one	1-2	3-4	5-9	10-14	15-19	20-25	26-30	above 30	total above 3″ dbh
Acer negundo	10									
A. rubrum	3	8								
A. saccharum	51	43	25	22	11		1			59
Carpinus caroliniana	13	4								
Carya cordiformis	4	1				1				1
C. glabra	1	1	1			2				2
C. ovata			1							1
Celtis occidentalis	13									
Cercis canadensis	2									
Cornus florida	3	1								
Fagus grandifolia	22	1	4	8						12
Fraxinus americana	21							1		1
Liriodendron tulipifera	11	1						1		1
Ostrya virginiana	8		1							1
Quercus alba	2	4	4	2						6
Q. rubra	2						3	1	2	6
Q. velutina	43							1		1
Sassafras albidum	20				2					2
Tilia americana	3									
Tsuga canadensis	8	7	1	1		1	3			6
Ulmus americana	38	1			3	1				4
U. rubra			1							1
Total	359									104

Stand Reprod. density — 496/acre

Stand Density — **144/acre**

TABLE 3—Forest Attributes for Principal Tree Species of North and South Facing Slopes
(F_3 = relative frequency; D_3 = relative density; B_3 = relative basal area; V_3 = importance value; B_9 = Stand basal area in sq. ft. per acre)

	F_3		D_3		B_3		V_3		V_3 Upland Forest
	N	S	N	S	N	S	N	S	
Acer saccharum	32.4	40.9	38.3	54.8	31.2	26.8	34.0	32.0	39.5
Fagus grandifolia	18.9	13.1	17.7	11.5	21.7	3.2	19.5	8.2	12.4
Quercus rubra	6.8	8.2	6.5	5.8	6.5	30.9	6.6	14.8	7.1
Tsuga canadensis	9.45	8.18	10.3	4.8	14.9	.70	11.58	4.36	0.0
Q. alba	4.1	4.9	3.7	5.8	1.0	1.1	2.9	3.7	7.1
Q. velutina	2.7	3.3	1.9	1.9	3.0	2.1	2.5	1.7	2.7
Sassafras albidum	5.4	1.6	6.5	1.9	3.7	2.1	5.2	1.2	4.9
Ulmus americana	2.7	3.3	1.9	3.8	1.0	5.3	1.9	2.4	3.5
Ostrya virginiana	5.4	1.6	4.7	1.0	0.1	1.1	3.7	0.9	.19
Liriodendron tulipifera	2.5	1.6	0.9	1.0	0.8	5.8	1.0	0.9	14.3
Carya glabra	2.7	4.9	1.9	2.9	0.3	4.3	1.6	2.6	1.48
C. ovata	0.0	1.6	0.0	1.0	0.0	0.1	0.0	0.9	.9
C. cordiformis	0.0	1.6	0.0	1.0	0.0	2.1	0.0	0.9	1.16
Cornus florida	1.4	0.0	0.9	0.0	0.1	0.0	0.8	0.0	.99
Fraxinus americana	0.0	3.3	0.0	2.0	0.0	6.1	0.0	0.8	2.8
				B_9	101.7	117.0			

Conclusions

Friesner and Potzger (1) working in Brown and Bartholomew counties, reported a definite moisture stress occurring on south-facing slopes during late spring and summer. Potzger (6) found that "surface soil had 30% and soil at six inches had 28% more moisture on the north than on the south-facing slope." He also measured evaporation losses 61% greater on south-facing slopes. From their forest stand analyses, they concluded that "the transition from Beech-Maple on the north-facing slopes to Oak-Hickory on the south-facing slopes is not gradual, but abrupt and decisive." The current study indicates that in narrower valleys of physiographic areas, younger than those studied by Friesner and Potzger, the transition from South to North slope is not abrupt for the majority of species, rather they grade into greater or lesser expression, measured only occasionally by the absence of certain dominant species, the transition being expressed primarily as a variation in density, frequency, growth rate and total number of species.

Literature Cited

1. Friesner, R. C. and J. E. Potzger. 1937. Contrasts in certain physical factors in Fagus-Acer and Quercus-Carya communities in Brown and Bartholomew Counties, Indiana. Butler University Bot. Stud. 4:1-12.

2. Gleason, H. A. and Arthur Cronquist. 1963. Manual of vascular plants of the Northeastern United States and adjacent Canada.

3. Jackson, M. T. 1964. Microclimatic differences and their effects upon spring flowering phenology. Ph.D. thesis—Purdue University.

4. Lindsey, A. A. 1956. Sampling methods and community attributes in forest ecology. For. Science 2(4):287-296.

5. Potzger, J. E. 1935. Topography and forest types in central Indiana region. Amer. Midland Nat. 16:212-229.

6. ————. 1939. Microclimate and a notable case of its influence on a ridge in central Indiana. Ecology 20(1):29-39.

7. Wayne, W. J. 1951. An introduction to the geology of Parke County, Indiana. Indiana Dept. of Conserv. Geol. Surv. Circular No. 2. Bloomington, Indiana.

Castilleja coccinea in the Yellow Form

GAYTON C. MARKS, Valparaiso University

In the Flora of Indiana Deam (1) states that *Castilleja coccinea* (Indian Paintbrush) is rare or extinct over most of Indiana but could be found in the northwest part of the state in the borders of sloughs between dunes. He points out that it could be especially abundant in Lake County, and he indicates there had been sporadic reporting from the southwestern part of the state. Plant Distribution Records since that time reports it from Franklin County. (2)

C. coccinea is a member of the Schropulariaceae. Plants of this genus are known for their brightly colored leaves, and it is this characteristic which is distinctive.

The common color indicated by Deam for this species is red, and he states yellow bracts are infrequent. Cronquist and Gleason (3) describe *C. coccinea* as possessing bracts which are mostly or wholly scarlet and rarely pale. Gray's Manual of Botany (4) describes a forma *Lutescens* which is yellow but does not indicate comparative frequency. Peattie (5) says in the Flora of the Indiana Dunes the plant is rare but does not distinguish between yellow and scarlet forms in frequency of occurrence.

The only form found in Lake County in the early summers of 1963-64 was the yellow bracted type. Although this form of the species seemed limited to a small geographical area (about 1 sq. mile) a relative abundance of yellow individuals could be noted.

These plants were found in central Lake County not too far from the northeastern town limits of Schererville, Township-35N; Range, 9 W.

The typical habitat is a moist, sandy prairie predominantly populated by grasses. In one situation a very prosperous colony had located in an overgrown apple orchard.

It was hoped within the broad spectrum of individual variation, a red bracted specimen could be found among the yellow. A few individuals were detected to range from slightly tinged with red to deeply tinged. Although these individuals were rare, some nearly approached a reddish-orange. They were, however, still so much nearer the yellow form that they could not be mistaken for red or scarlet.

Since the red form was found and photographed in neighboring Porter County, it may be assumed that the red form could exist in Lake County.

Literature Cited

1. Deam, Charles C. 1940. Flora of Indiana. Department of Conservation, State of Indiana.
2. Indiana Plant Distribution Records, VIII. 1947. Proc. of the Ind. Acad. of Sci.**57**:85.
3. Gleason, Henry A. and Arthur Cronquist. 1963. Manual of Vascular Plants of Northeastern United States and Adjacent Canada.
4. Fernald, Merritt L. 1950. Gray's Manual of Botany. 8th Ed.
5. Peattie, Donald C. 1930. Flora of the Indiana Dunes. Field Museum of Natural History, Chicago.

A Twice Taken Qualitative and Quantitative Sampling of Phytoplankton in Four Areas of Dewart Lake, Indiana

Sue E. Harper and Cameron E. Gifford, Earlham College

Introduction

In any limnetic investigation dealing with primary productivity, it is essential to make qualitative and quantitative evaluation of the primary producers, i.e., the phytoplankton. As one part of an overall investigation being carried out at the David Worth Dennis Biological Station on Dewart Lake, located in Kosciusko County in northern Indiana, it is the purpose of this paper to present the results of some preliminary studies of the phytoplankton of this lake.

On July 15 and 23, 1964 phytoplankton samplings were taken in four locations in the limnetic zone of Dewart Lake within one meter of the surface. Qualitative and quantitative analyses were determined for each sample with comparison made between areas.

Methods

Samples of phytoplankton were taken with the Clarke-Bumpus qualitative plankton sampler using a No. 20 net at a depth of ¾ meter. Samples were taken in the early afternoon and on both sampling dates the weather was clear with a recorded temperature between 85-90°F. The alga collected were identified by using keys of Prescott (1951) and Smith (1950). Also, Mr. William A. Daily from Lilly Research Laboratories and Mr. John Winters, the stream biologist of the Indiana State Board of Health, helped with the identification work.

The samples were taken to the laboratory in oxygen bottles where 10 ml. of 3% formalin was added to each bottle. The volume of each sample was measured and the bottles were then placed in the refrigerator until counts were made. Five counts were made from each bottle. Each count was composed of 10 random drops. Counting was done on glass slides with a Unitron mechanical-stage microscope at a magnification of 150 times. Quantitative calculations were made by taking the average of the 5 counts and fitting this average into the following formulas.

$$\frac{\text{vol. of sample}}{.576 \text{ ml}} \times N = T$$

$$\frac{T}{1} = \text{organisms per liter}$$

576 = average measured volume of 10 drops from the eyedropper
N = average number of the individuals of a species in one 10 drop sample
T = total number of individuals in the sample bottle
1 = number of liters of lake water filtered

Results

The species as listed in Table 1, represented 99% of the phytoplankton types observed. Because of their greater abundance these were the only 12 species considered in the quantitative study. The

other 1% not considered was composed of such genera as *Mougeotia, Schroederia, Urococcus, Asterionella, Navicula, Aphanizomenon, Oscillatoria,* and *Agmenellum.* These occurred in such low frequency, throughout the quantitative analysis, that we consider them insignificant.

TABLE 1

Chlorophyta	*Pediastrum Boryanum* (Turp.) Menegh.
	Microspora stagnorum (Kuetzing)
	Staurastrum sp.
Chrysophyta	*Melosira granulata* (Ehrenb.) Ralfs.
	Cyclotella Meneghiniana Kutz.
	Fragilaria crotonensis Kitton
Pyrrhophyta	*Ceratium hirundinella* (O.F.M.) Schrank.
Cyanophyta	*Anacystis cyanea* (Kuta) Drouet and Daily
	Gomphospaeria Wichurae (Hilse) Drouet and Daily
	Anabaena circinalis (Kutz.) Rabenh.
	Lyngbya Birgei G. M. Smith.

The rotifer, *Keratella,* was also included in the counts because of its quantity at ¾ of a meter.

As shown in Fig. 1, the four species *Lyngbyra, Anabaena, Anacystis* and *Melosira* occur in the greatest quantities and this could be considered the most significant in this study.

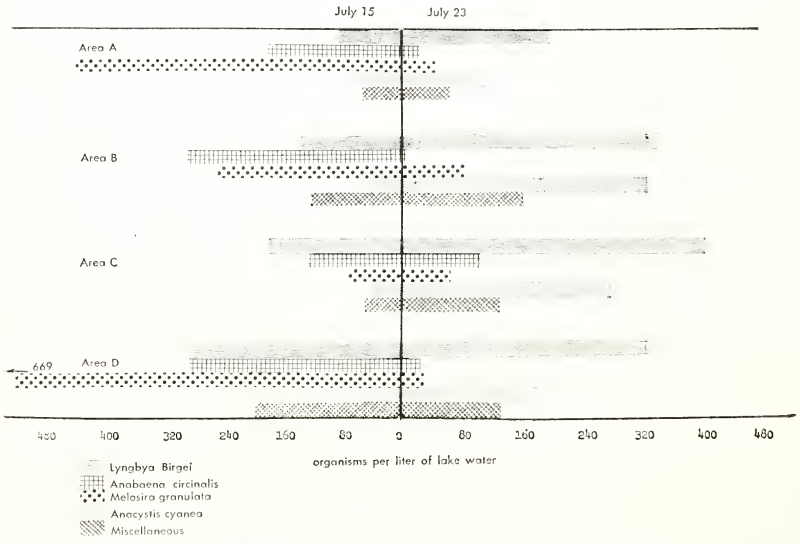


Figure 1. Quantities of the 4 major phytoplanktors in Dewart Lake.

From Fig. 1, two qualitative aspects can be considered, 1, variation in number of the same species in the four different areas and 2, variations in numbers of the same species within one of the areas during the 8 day interval. In dealing with both aspects, it was clearly evident

that no type of consistency exists. *Melosira sp.* occur in quantities of 440/liter and 699/liter in areas A and D respectively while occurring in areas B and C in considerably lower frequency.

Variations within the individual species during the 8 day interval were even more extreme with both increases and decreases evident. Again as best exemplified in *Melosira*, 10 fold changes or greater occurred within areas A and D. In all species considerable change was noted. Other species including *Ceratium hirundinella, Dinobryon sociale, Gomphosphaeria Wichurae, Fragilaria crotonensis, Pediastrum Boryanum, Cyclotella Meneghiniana, Keratella,* and *Staurastrum* were plotted together under miscellaneous. Here again the pattern of variations was clear.

In Table 2, a comparison of total phytoplankton for the same area is shown for the beginning and end of an 8 day period.

TABLE 2

Total Phytoplankton Per Liter of Lake Water

	July 15	July 23
Area A	822.32	453.96
B	842.91	925.92
C	475.14	992.37
D	1,520.91	805.14

In both areas A and D there is a 50% reduction in the total phytoplankton after eight days while in area C there is a 100% increase and in area B there is relatively little change. No explanation for this change is possible at this time.

Discussion

It would seem that in dealing with the limnetic zone of any large body of water, the various ecological factors controlling the growth of population would be relatively constant. However, there is a continual fluctuation in certain major species of phytoplanktons in this lake. In all four areas *Lyngbya Birgei, Anacystis cyanea, Keratella,* and *Gomphospaeria Wichurae* increased in total abundance after the eight days, while *Anabaena circinalis* and *Melosira granulata* decreased. *Dinobryon sociale, Ceratium hirundinella, Fragilaria crotonensis, Pediastrum Boryanum, Cyclotella Meneghiniana,* and *Staurastrum* showed little or no fluctuations.

These great variations in the numbers of phytoplanktons observed in the short interval must be attributed to the complex interaction of several factors. The qualitative penetration of light in water is one important factor. The depth to which rays are able to penetrate the water is dependent upon the amount of dissolved salt, the turbidity, and the color of the water. Light intensity at 1 meter in Dewart Lake was determined to be approximately ½ that of the surface. Because of the shallow depth and the lack of clouds, the light factor was relatively constant on both days of samplings and during the eight day period. Temperature is another factor that plays a role in the accelera-

tion or retardation of algae growth. Here again there was little or no difference in the temperature over the eight days, and certainly no differential in the four areas. The inorganic compounds of magnesium and calcium can also be considered important in influencing the total number of alga present at any given time. These two elements are important because their bicarbonates furnish a supplemental supply of carbon dioxide for phytosyntheses. However, because of relative hardness of this lake, both elements are in abundance. Smith (1950) indicates that the organic compounds dissolved in water also greatly affect the algae flora, although he adds that the relationship is so complex that it is impossible to determine. One factor to which little significance has been attributed is the mixing or disturbance of surface water by high speed outboard motors. Though no direct cause can be determined for the observed fluctuations, continual agitation, the addition of small amounts of oil and gas, may affect these surface plankton to considerable extent. It has also been observed that certain areas of the lake receive far more motor abuse than others.

Summary

Phytoplankton samplings taken with the Clark-Bumpus quantitative plankton sampler on July 15, and July 23, 1964 showed that all species observed were found in all four areas of the lake studied. The second sampling taken after eight days showed considerable fluctuations in the relative total abundance of the species within each area. *Lyngbya Birgei*, *Anacystis cyanea*, and *Gomphospaeria Wichurae* increased in abundance in all four areas. *Anabaena circinalis* and *Melosira granulata* decreased in abundance in the four areas. In comparing each area with itself after the period of eight days as well as comparing each area with other three areas, there was considerable variation in the total number of phytoplankton observed.

Literature Cited

Daily, W. A. 1938. A Qualitative Study of the Phytoplankton of Lake Michigan Collected in the Vicinity of Evanston, Illinois. Butler University Botanical Studies.

Daily, W. A. 1958. In Search of Some Blue-Green Wanderers. Indiana Academy of Science. **68.**

Daily, W. A. 1953. The Phytoplankton of Lake Wawasee, Kosciusko County, Indiana. Butler University Botanical Studies. **11.**

Prescott, G. W. 1954 How to Know the Fresh-Water Algae. Wm. C. Brown Co.

Prescott, G. W. 1951. Algae of the Western Great Lakes Area. Cranbrook Institute of Science. Bulletin **No. 31.**

Smith, G. M. 1950. The Fresh-Water Algae of the United States.

Tiffany, L. H. and M. E. Britton. 1952. The Algae of Illinois. The University of Chicago Press.

SOIL SCIENCE

Chairman: JOHN M. ROBBINS, JR., U.S.D.A. Soil Conservation Service
HELMUT KOHNKE, Purdue University, was elected chairman for 1965

Some Characteristics of Purdue Soil Testing Data From Field Plots[1]

RUSSELL K. STIVERS, Purdue University[2]

The objective of this research was to study changes in Purdue soil testing data related to liming and fertilization. Barber and Stivers (1) have reported that increases in phosphate soil test level as a result of phosphate fertilization are related to the initial soil test level of phosphate. These increases, however, may be masked due to variation involved in the two separate samplings (before and after) being compared. It was thought that, by using small plots and doing a thorough job of sampling, an accurate measure of the increase could be obtained. Barber (2) also studied the relation of different potash soil test levels to cropping, but he did not report clearly both his beginning and ending levels.

Methods and Procedure

One composite soil sample from each field plot of several fertilizer experiments was taken in late spring, prior to the initiation of each experiment. Other composite samples were taken from the same plots each year thereafter, that the experiment was continued. These soil samples were taken just before fertilizer was applied and before corn or soybeans were planted in the spring.

Composite samples consisted of 15 or more Hoffer tube cores per plot, taken in the harvest area to a 7 inch depth. In 1962, these cores were hand mixed, and a pint was taken for the tests. In the following two years the composite sample was not hand mixed and subsampled prior to submission for the tests. Rather, the whole of the 15 or more cores was submitted for the tests.

Soil tests on all samples were conducted by the Purdue Soil Testing Laboratory using the procedures of Spain and White (4, 5).

Results and Discussion

The initial soil sample data taken just prior to the initiation of fertilizer research at five locations are summarized in Table 1. At all locations phosphate soil test data were most variable as shown by the coefficient of variation. Potash soil test data were nearly as variable. Inasmuch as these fields had been selected for uniformity, it was dif-

[1] Journal Paper No. 2431, Purdue University Agr. Exp. Sta.

[2] The author acknowledges the cooperation of Donald R. Griffith and John R. Hodges and the help of John Bognar, Raymond Wagoner, N. Thomas Houghton, James A. Purdy, and Leo A. Duclos in conducting this research.

TABLE 1

Characteristics of portions of Indiana farm fields as described by Purdue soil testing data prior to the initiation of fertilizer experiments.

Soil type or types	Area acres	Location	Year sampled	Purdue soil test	No. of plots in sample	Sample means	Standard Error of individuals	Coefficient of variation	Range
Runnymede 1.	1.19	Porter	1962	pH	45	6.17	0.114	1.84%	6.0- 6.4
				P_2O_5 Lbs./A.	45	227	44.8	19.7	127 -292
				K_2O_5 Lbs./A.	45	183	23.8	13.0	151 -250
				Color	45	23.0	0.0	0.0	0
				Texture	45	4.00	0.0	0.0	0
Blount sil.	1.73	Randolph	1962	pH	66	6.72	0.173	2.58%	6.2- 7.0
				P_2O_5 Lbs./A.	66	114	47.7	41.8	46 -271
				K_2O, Lbs./A.	66	185	44.8	24.2	133 -349
				Color	66	74.0	0.0	0.0	0
				Texture	66	4.00	0.0	0.0	0
Russell sil. Reps. II & III	117	Tippecanoe	1963	pH	84	5.56	0.458	8.18%	5.0- 6.7
Fincastle sil. Rep. I	0.58			P_2O_5 Lbs./A.	84	40.2	12.7	31.8	19 - 89
				K_2O, Lbs./A.	84	128	25.2	19.7	79 -220
				Color	84	75.2	0.72	0.96	74 - 76
				Texture	84	4.00	0.0	0.0	0
Crosby sil.	2.09	Tippecanoe	1963	pH	85	5.69	0.279	4.90%	5.1- 6.4
				P_2O_5 Lbs./A.	85	27.9	18.6	66.7	9 -126
				K_2O, Lbs./A.	85	102	27.1	26.6	58 -140
				Color	85	74.5	3.09	4.15	64 -85
				Texture	85	4.00	0.00	0.0	0
Martinsville sil. (2 Exp.)	2.38	Tippecanoe	1964	pH	114	6.56	0.219	3.34%	5.8- 7.1
Russell sil. (1 Expt.)				P_2O_5 Lbs./A.	114	76.5	73.5	96.1	34 -800
				K_2O, Lbs./A.	114	173	73.3	42.4	101 -720
				Color	114	75.0	0.00	0.0	0
				Texture	114	4.00	0.00	0.0	0

TABLE 2
Relation of Purdue phosphate soil test levels to phosphate fertilization on two Indiana soils

Soil	Crop	Experiment	No. of plots in ave.	1962 Level Lbs./A. of P_2O_5 soil test	1962 Lbs./A. of P_2O_5 applied as fertilizer	1963 Level Lbs./A. of P_2O_5 soil test	1963 Lbs./A. of P_2O_5 applied as fertilizer	1964 Level Lbs./A. of P_2O_5 soil test	Build-up of Phosphate in Lbs./A. of of P_2O_5 per 100 Lbs./A. of P_2O_5 applied in fertilizer: These Exp'ts.	Barber's Exp'ts.
Blount sil	Soybeans	Phosphate	3	134	0	141	0	154	—	—
	"	"	3	155	30	171	30	176	35	95
	"	"	3	142	60	136	60	168	22	92
	Average			144	—	150	—	166	—	—
	LSD — 5%			N.S.		N.S.		N.S.	.....	.....
	No significant difference when all years were combined									
Blount sil	Corn	Phosphate	3	104	0	101	0	110	—	—
	"	"	3	111	28	112	28	137	46	79
	"	"	3	98	78	143	78	151	34	73
	"	"	3	98	128	123	128	192	37	73
	Average			103	—	120	—	147	—	—
	LSD — 5%			N.S.		N.S.		N.S.	.....	.....
	LSD — 5%	among years 41 Lbs./A. of P_2O_5 soil test.								
	LSD — 1%	among years 25 Lbs./A. of P_2O_5 soil test.								
Crosby sil.	Corn	Phosphate	6	—	—	24	0	33	—	—
	"	"	6	—	—	16	150	94	52	13
	"	"	6	—	—	38	300	178	47	30

TABLE 3

Relation of Purdue Potash Soil Test Levels to Potash Fertilization on Three Indiana Soils

Soil	Crop	Experiment	No. of plots in ave.	1962 Level Lbs./A. of K_2O soil test	1962 Lbs./A. of K_2O applied as fertilizer	1963 Level Lbs./A. of K_2O soil test	1963 Lbs./A. of K_2O applied as fertilizer	1964 Level Lbs./A. K_2O soil test	Change in level of K_2O soil test in percent
Blount sil.	Soybeans	Potash	3	187	0	184	0	191	+ 2.1
	"	"	3	194	30	191	30	189	— 2.6
	"	"	3	191	60	182	60	187	— 2.1
	"	" Average		191	—	186	—	189	— 1.0
Blount sil.	Corn	Potash	3	149	0	181	0	195	+ 23.6
	"	"	3	173	40	180	40	195	+ 12.7
	"	"	3	155	80	196	80	215	+ 38.7
	"	"	3	182	120	229	120	236	+ 29.7
	"	" Average		165	—	197	—	210	
		LSD — 5%		N.S.		15		N.S.	
		LSD — 1%		N.S.		22		N.S.	
	There is no significant difference among years.								
Runnymede l.	Soybeans	Potash	3	169	0	120	—	—	— 29.0
	"	"	3	174	20	111	—	—	— 36.2
	"	"	3	164	40	121	—	—	— 26.2
	"	" Average		169		117			
		LSD — 5%		N.S.		N.S.			
	There is no significant difference among years.								
Runnymede l.	Corn	Potash	3	169	0	143	0	170	+ 0.6
	"	"	3	179	40	145	40	187	+ 4.5
	"	"	3	183	80	155	80	207	+ 13.1
	"	"	3	204	120	147	120	221	+ 8.3
		Average		184		147		195	
		LSD — 5%		N.S.		N.S.		N.S.	
		LSD — 5% among years was 33 Lbs./A.							
Crosby sil.	Corn	Potash	3	—	—	100	0	133	+ 33.0
	"	"	3	—	—	110	180	183	+ 66.4
	"	"	3	—	—	105	360	270	+157.1

ficult to see how so much variation could exist. Even though uniformly cropped the previous few years, these fields apparently had not been uniformly fertilized. Variation in fertilization may have occurred some years previously due to stopping a fertilizer spreader, pasturing livestock, locating strawstacks on the area, locating building on or near the experimental area, or cropping differently many years ago.

On the Martinsville and Russell soil locations very high phosphate and potash soil test values were located along the south edge of the experimental area, possibly where a lane used by livestock had been at one time.

Soil pH varied relatively less from plot to plot than the phosphate and potash soil testing data. However, the range in soil pH values was greater than expected in three of the five locations. On the Russell and Fincastle soils location proximity to a gravel road resulted in a higher pH level in the replication nearest this road.

Soil color and texture varied less than all other soil testing data.

Changes in phosphate soil test levels are a result of phosphate fertilization are given in Table 2. There was a trend toward higher levels in soil phosphate on those treatments receiving the higher rates of phosphate fertilizer. On the Blount soil this trend did not result in significantly higher phosphate soil test levels on either the corn or the soybeans experiments. There was some indication of increasing phosphate soil test levels on the Blount soil even where no phosphate fertilizer had been applied.

Changes in potash soil test levels as a result of potash fertilization are given in Table 3. There was a trend toward higher soil test levels of potash on the Blount and Crosby soils where several rates of potash fertilizer were applied for corn. However, on the Blount soil used for corn, there was a 23.6 percent increase in soil test level from 1962 to 1964, even though no potash had been applied. One hypothesis is that high rates of nitrogen and phosphate fertilizer (which were used on all rates of potash plots) stimulated soil microbial action so that previously unavailable soil potash became available. However, if this were true it is believed that it should also have happened on the Runnymede loam with corn.

There was a large decline from 1962 to 1963 in potash soil test levels in the potash experiment with corn on Runnymede loam. This decline of 37 Lbs. per A. was significant at the 5 percent level of probability. No good reasons for this decline are known. It is possible, although not thought to be probable, that the 1963 decline in potash soil test levels was related to soil moisture content at the time of sampling. This decline can not logically be ascribed to errors in testing procedure because at least one standard soil is tested with each tray of samples. Furthermore, Golke and Baumgardner (3) conducted experiments in which they retested the same soil samples. Twenty Lbs. per A. of potash was the biggest difference reported among triplicate samples.

Liming two different soils, the Crosby and the Runnymede, at rate of 2 or 2¼ T. per A. resulted in an increase of 0.1 to 0.15 pH unit

in one year. However, on the other soils where no lime was applied, pH changes were about the same in magnitude, although sometimes they decreased. In several experiments soil pH levels did not change in the two year period.

Soil color and texture of the same field plots varied little or none from year to year.

Summary

Composite plow layer soil samples were obtained from the same field plots for two or three consecutive years. These samples were tested routinely in the Purdue Soil Testing Laboratory. These initial soil samples from small plots in relatively small areas of farmers' fields, showed great variation in phosphate and potash soil test values. Soil pH varied less and soil color and texture varied little or none at all.

Increasing rates of phosphate fertilization tended to result in increasing soil test levels of phosphate. The build-up or increase of phosphate soil test levels was, in general, less than that reported by Barber.

Samples taken both years following the initial application of increasing rates of potash fertilizer showed differing changes in potash soil test levels. It was impossible to logically explain the large decrease in potash level which occurred on the Runnymede loam the first year following potash fertilizer application.

Changes in soil pH values were small even after 2 T. per A. of agricultural limestone had been applied. Soil color and texture changed very little or none at all.

Literature Cited

1. Barber, S. A. and R. K. Stivers. 1963. Phosphorus fertilization of field crops in Indiana—research prior to 1963. Purdue Univ. Res. Bul. **759**:1-28.
2. Barber, S. A. 1959. Relation of fertilizer placement to nutrient uptake and crop yield: II Effects of row potassium, potassium soil level, and precipitation. Agron. Jour. **51**: 97-99.
3 Golke, A. F. and M. F. Baumgardner. 1960. Statistical evaluation of analytical techniques employed in the Purdue Soil Analysis Laboratory. Proc. Ind. Acad. Sci. **70**:248-253.
4. Spain, J. M. and J. L. White. 1960. pH and lime requirement determination. Purdue soil testing mimeograph.
5. Spain, J. M. and J. L. White (no date). Procedure for the determination of phosphorus and potassium. Purdue soil testing mimeograph.

Soil Survey Saves Lake County Taxpayers' Money

Robert Montgomery and Kenneth A. Wenner[1]

A progressive soil survey of Lake County was started in April 1963. At that time approximately 80,000 acres had already been surveyed for agricultural purposes. The field work is expected to be completed by the end of 1965 and the report to be ready for publication by 1967.

Three soil scientists with the Soil Conservation Service and two from Purdue University are actively working on the soil survey. In addition the Cooperative Extension Service and the Lake County Commissioners have hired a soil scientist to do educational work and special soil interpretations.

Lake County has over 300 soil phases. The soils are developed from Wisconsin age till, glacial outwash, and lacustrine deposits. In the northern and southern quarters of the county the soils are predominantly sandy, while in the central half the soils are predominantly developed in silty clay loam or clay loam till.

The northern third of the county is now predominately urban while the central third is interspersed with urban development and agriculture. The southern third is mainly agricultural. The county population is now approaching 550,000 or 13 percent of the population of Indiana. One percent of the people are actively engaged in farming.

A large percentage of the recent population increase is located in the 50 new subdivisions platted since 1950 outside of municipal corporations. The biggest problem faced by the subdivisions is sewage disposal. The earlier units were developed in sandy soils, which were satisfactory for the use of septic tanks; however, with the increasing demand for space, the newer units were platted on the more clayey soils. It soon became apparent that clay soils were unsuitable for septic systems unless the lot sizes were larger. To help meet this problem, the soil scientists worked with the County Health Department and the Lake County Plan commission to evaluate the soils in proposed sub-divisions and determine the minimum lot size. In some cases complete subdivision sites were turned down for septic tank usage because the soil survey indicated the soils to be too impervious.

Health Department regulations on the use of septic systems are based on the soil percolation rate, or the rate at which water will soak into the soil as measured in minutes per inch. These rates are established by the contractor on each site. The rates were variable due to existing soil moisture conditions and length of pre-saturation on the same soil. To save the contractor time and money, an estimated rate has been established for each soil. These estimates were determined by conduct-

[1]Soil Scientist, U. S. Soil Conservation Service; and County Extension Agent, Indiana Cooperative Extension Service. Crown Point, Indiana.

ing tests on selected soil types. The Health Department is finding these pre-established and estimated rates more accurate and reliable than tests formerly submitted by engineering firms. Each proposed unit must now have a complete soils map with interpretation before approval by the Lake County Plan Commission.

In addition to the subdivision work, the soil survey has been used extensively by the Lake County Plan Commission staff in the preparation of a proposed land use plan and zoning map for the entire county. In the preparation of these plans, the soils have been interpreted as to their potential for: agriculture, subdivisions, estate type with septic tanks and small lots with sewers; recreation, both developed and natural; and industrial and commercial uses.

The demand for land has put pressure on the use of flood plain soils for building and development. A proposed flood control and drainage project for the little Calumet river basin was estimated by the Army Corps of Engineers to cost $47 million dollars. To realize a tax benefit from the protected areas, a very intensive land use is needed. Prior to the soil survey, a land use plan has been tentatively proposed. This proposal was delayed pending the results of the soil survey. When the soils were evaluated, it was found necessary to change many of the proposals.

The value of the survey was realized during the investigations of several school sites. One site consisted of approximately 40 acres. The proposed usage was for a school building and a large parking area. The building was to be located on a relatively level sand ridge and the parking lot was to extend into the lower adjacent area. This latter area consisted of an average of 4 feet of muck over sand. The cost to remove this muck was estimated at $40,000. Another site was to be an addition to an existing structure. The architect had proposed a 3 foot deep footing all the way around the building. The top 3½ feet of soil material consisted of yellow clay fill; but beneath the fill material existed several drainage channels with soft silts extending to a depth of at least five feet.

Another way in which the soil survey saved Lake County money was the discovery of gravel in the southern part of the county. Previous to the soil survey, no large commercial deposits were known. Because of the rapid growth of the county, much gravel is needed for roads and public works. The nearest gravel source or limestone deposit had been some 60 miles from the Gary area. The new deposit, which is estimated to contain 7 millions tons of gravel and sand, is within 25 miles. The hauling bill alone will be a huge saving to taxpayers and private enterprise alike.

Use of the soil survey for land appraisal became a reality during the buying of land for Interstate Route 65. The appraisers for the state evaluated the potential of a farm based on the soils data. This data was then compared with the recent sale of farms having similar soils in the same general area.

The city of Munster in Lake County became the first community to have a completely urban soil survey report. The local Chamber of

Commerce was willing to provide money for publishing the report and maps if the information was compiled for the area. The report was completed in June, 1964, and includes only urban soils interpretations. The main topics included were: flooding and drainage; turf and plant materials guide; soil interpretative ratings for roads, buildings, and land use; and an engineering table. Other communities have seen this report and are interested in similar reports on a local basis.

Soil Associations of Perry County

JOHN M. ROBBINS, JR., U.S.D.A. Soil Conservation Service

Perry County is located in the southern part of Indiana and has an area of 245,760 acres or 384 square miles. The Ohio River forms the southeast and south boundary which is the Kentucky state line. The County is bounded on the west by Spencer and Dubois counties; on the north by Dubois and Crawford counties; and on the east by Crawford County. Cannelton is the County seat.

The County is drained by several small watersheds that drain directly into the Ohio River. The sloping ridgetops are used for cropland and pasture; steeply sloping hillsides for forestry or pasture; and the nearly level bottom lands for cropland.

In Perry County the oldest soils have developed from residual sandstone, shale, siltstone and limestone. The soils derived from lacustrine materials are developed in deposits of the Wisconsin Drift. These lacustrine soils occur along the valleys of streams and at the conjunction of the streams with the Ohio River. The young soils are the shallow residual soils usually occurring on steep slopes where natural erosion is nearly as rapid as soil formation and the bottom lands soils where new materials are deposited periodically. Sandy aeolian material in the upland adjacent to the Ohio River was deposited during or after the time of the Wisconsin glacial period. Soils developed in this material are less thoroughly and not as deeply leached as those generally developed in residium. They have immature profiles.

After study of the soils in Perry County and the way they are arranged, it is possible to make a general map that shows several main patterns of soils, called soil associations (Fig. 1). Each association, as a rule, contains a few major soils and several minor soils, in a pattern that is characteristic although not uniform.

The soils within any one association are likely to differ from each other in some or in many properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general soil map shows, not the kind of soil at any particular place, but patterns of soils, in each of which there are several different kinds of soils.

Each of the five soil associations is named for the major soil series in it, but as already noted, soils of other series may also be present. The major soils of one soil association may also be present in other associations, but in different patterns.

The general map showing patterns of soils is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

Association 1

Gilpin-Muskingum-Wellston Association: Moderately deep to deep, well drained, sloping to extremely steep upland soils.

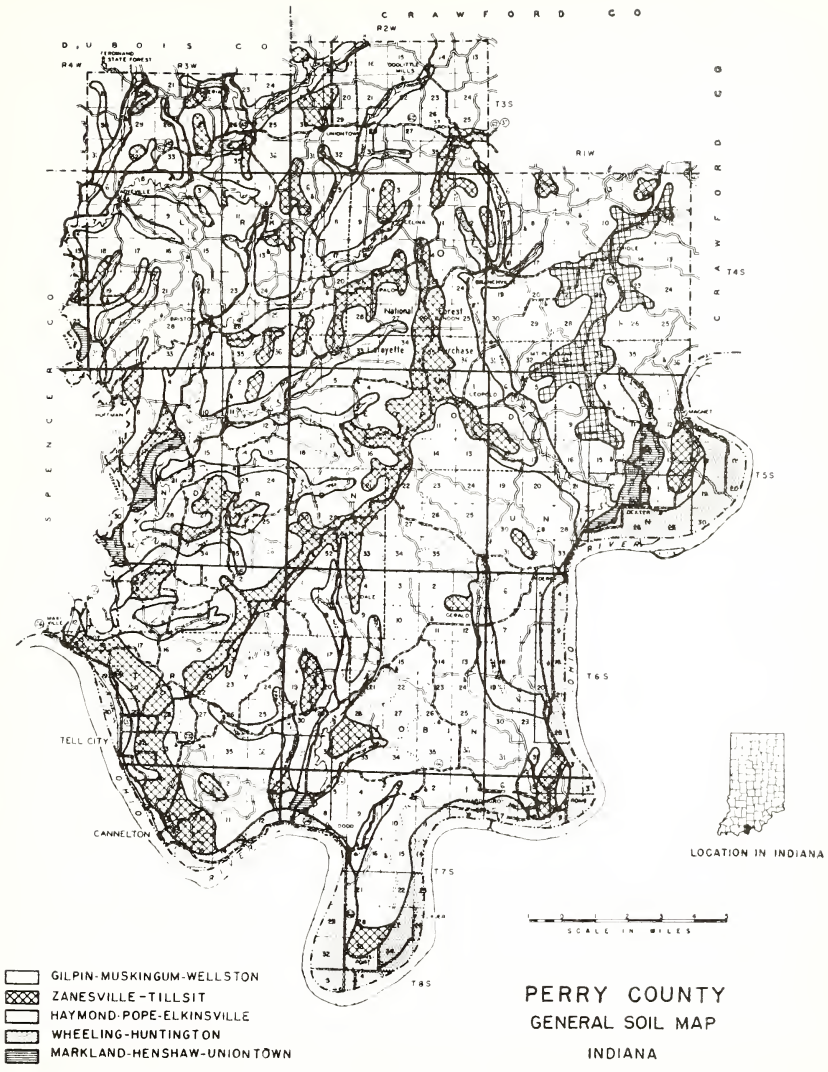


Figure 1. General Soils Map — Perry County, Indiana

This soil association occupies about 54 per cent of the land area in Perry County. It occurs in all areas of the upland soils in the County.

The Gilpin-Muskingum soils are the major soils and comprise about 70 per cent of the association. They are moderately dark colored, moderately deep, well drained, and are developed from acid gray sandstone, siltstone, and shale. These soils occur on sloping to extremely steep slopes.

The Wellston soils make up about 29 per cent of this association. They are light colored, moderately deep to deep, well drained, and are formed in 20 to 25 inches of slit which overlies material weathered from sandstone, siltstone and shale. In strongly sloping topography they are found on the long side slopes while in the steep areas they are found adjacent to the ridgetop, on benches of the side slopes and occasionally on the foot slopes.

The Corydon soils are a minor soil of this association making up about 1 per cent. They are moderately dark colored, shallow, well drained and are formed in material weathered from limestone. These soils occur on steep and very steep slopes mainly on the east side of the County north of Rome and near Branchville.

Most of the soils in this association are used for woodland with minor areas being used for pasture and cropland. Where these soils are cleared and used for cropland and pasture, erosion is a problem. The Muskingum and Corydon soils are somewhat droughty during periods of low rainfall.

Association 2

Zanesville-Tilsit Association: Moderately deep, well drained and moderately well drained soils with fragipans on gently sloping to strongly sloping upland areas.

The soils in this association occupy about 24 per cent of the County and are developed in silts over sandstone and shale. This is the second largest association in the County.

The Zanesville and Tilsit soils comprise about 81 per cent of Association 2. They are moderately dark colored, moderately deep, well and moderately well drained, and are formed in 18 to 48 inches of silt which overlies material weathered from sandstone, siltstone and shale. These soils have compacted layers occurring at a depth of about 28 inches which limit root penetration and moisture movement. They occur on gently sloping to strongly sloping ridgetops and slopes scattered throughout this association.

The Alford soils make up about 10 per cent of this association. They are light to moderately dark colored, deep, well drained and are formed in deep silts, 6 to 12 feet thick, underlain with acid sandstone, siltstone and shale. They occur on nearly level to steep slopes on uplands adjacent to the Ohio River.

Approximately 6 per cent of this soil association is composed of Pembroke soils. They are moderately dark colored, deep and well drained. They are formed in two different soil materials; the upper solum is developed in windblown silt and the lower solum is residium from limestone. These soils occur on gently sloping to strongly sloping rolling upland adjacent to the Corydon soils, along the eastern border of the County.

The Johnsburg soils are a minor soil of this association making up about 3 per cent. They are moderately dark colored, moderately deep, and somewhat poorly drained and are formed in 18 to 48 inches of silt which overlies material weathered from sandstone, siltstone and shale.

They occur on nearly level to gently sloping ridgetops near Apaloma and Mt. Pleasant.

Most of the soils in this association are used for cropland and pasture. The major management problems for soils in this association are erosion control on Zanesville, Alford and Pembroke soils, drainage on the Johnsburg soils and shallow root penetration limited by the fragipan on the Zanesville, Tilsit and Johnsburg soils. When cropped, rotations which include one to two years of row crops, one year of small grain and two years of meadow are recommended. This area is used dominantly for general livestock farming.

In the rolling areas erosion control practices such as terraces, diversions, sod waterways and contouring are used to slow down run-off and help in the control of erosion as well as effective use of living and dead cover.

Association 3

Haymond-Pope-Elkinsville Association: Deep and moderately deep, well drained nearly level to sloping stream bottom lands soils and old alluvial terrace soils.

This soil association occupies about 10 per cent of the land area in Perry County. These soils are adjacent to the streams. Small acreages of these soils occur in soil Association 1 adjacent to smaller streams that are too small in extent to be shown separately.

Approximately 46 per cent of the association consists of medium acid bottom land soils developed on the flood plain of streams draining upland which consist of mixed sandstone and shale. The moderately dark colored, deep and well drained Haymond soils predominate in most bottoms. There are smaller areas of moderately well drained Wilbur and somewhat poorly drained Wakeland soils. These soils occur in the Anderson River, Deer Creek, Poison Creek and Oil Creek bottoms and are subject to frequent flooding.

Approximately 33 per cent of this association consists of acid bottom land soils which occupy the flood plains of streams, draining the uplands of sandstone and mixed shale. The moderately dark colored, moderately deep and well drained Pope soils predominate in most bottoms. There are small areas of moderately dark colored, deep and well drained Stendal soils. These soils are strongly acid if not limed and overflow frequently.

Included in this association are some acid alluvial terrace soils, approximately 21 per cent, developed in stratified silts and some clays. They occur on slightly higher elevations then the bottoms and only overflow during periods of very high water. The moderately dark colored, deep and well drained Elkinsville soils predominate and have smaller areas of moderately well drained Pekin, somewhat poorly drained Bartle, and poorly drained Peoga soils.

Most of the soils in this association are used for cropland and pasture. Except for the old alluvial terrace soils, which are subject to frequent flooding. The somewhat poorly drained soils have an additional problem of wetness.

The wetness problem has been overcome on many of the areas by using open ditches and tile systems. Corn and soybeans are grown because they can be planted in late spring and harvested in early fall when floods are less likely to occur. Wheat, alfalfa, red clover and other crops that stand over the winter can be grown successfully only on the higher natural levees and terraces from which water recedes rapidly or in areas protected by man made levees. Moderate to high yields of corn are produced when these soils receive good management and fertilizers are applied according to the needs of the crop. Corn grown on these soils generally responds well to large applications of nitrogen.

Association 4

Wheeling-Huntington Association: Deep, well drained, nearly level to steep Ohio River terraces and bottom land soils.

The soils in this association occupy about 7 per cent of the County. They occur along the Ohio River near the east and south boundary of Perry County.

About 62 per cent of this soil association is composed of Ohio River terrace soils. The Wheeling soils comprise about 39 per cent of this association. They are moderately dark colored, deep and well drained. They are developed from noncalcareous waterlaid sands and silts underlain with sand, silt and some gravel with noticeable amounts of mica. The Weinbach soils make up about 12 per cent of this association. They differ from Wheeling soils by being somewhat poorly drained and by having moderately developed fragipans. The Sciotoville soils make up about 8 per cent of this association. They are moderately well drained and have moderately developed fragipans. Sequatchie soils are minor soils that make up about 2 per cent of the terrace area. They differ from the Wheeling soils by having a sandy solum rather than being developed in silt. They are less fertile and somewhat droughty. The Ginat soils make up about 1 per cent of this association. They are poorly drained and usually closely associated with the Weinbach soils. They occur near Tobinsport.

The Huntington soils make up about 18 per cent of this association. They are medium textured, moderately dark colored, deep, well drained and are formed from young alluvium washed from uplands dominated by limestone, loess and loess capped sandstone and shale soils. They occur in the Ohio River bottoms on nearly level areas subject to flooding.

Three other minor Ohio River bottom soils are Newark, Lindside and Bruno soils. Newark soils make up about 6 per cent of this association. They are moderately dark colored, deep and somewhat poorly drained. Lindside soils make up about 4 per cent of this association and they differ from Huntington soils by being only moderately well drained. The Bruno soils make up about 2 per cent of this association. They are moderately dark colored, deep and well drained bottom soils but differ from the Huntington soils in having sandy profiles.

The Woodmere soils make up about 5 per cent of this association. They are moderately dark colored, deep and moderately well to well

drained. They are formed in recently deposited neutral alluvial material from the Ohio River. This alluvium is 18 to 30 inches thick underlain with strongly acid soils developed in Ohio River sediments. These soils occur on level and nearly level second bottom areas above the Huntington soils along the Ohio River.

Another minor associated soil is the Rahm soils which make up about 1 per cent of this association. They differ from the Woodmere soils by being somewhat poorly drained.

The Princeton soils are a minor soil of this association making up about 1 per cent. They are moderately dark, deep, well drained, and are developed in wind-blown calcareous sand and coarse silt. These upland soils occur on long narrow dune ridges north of Tobinsport and near Dexter.

Most of the soils in this association are used for cropland and pasture. The major management problems on these soils are drainage on the somewhat poorly drained and poorly drained soils, overflow on the bottom land soils and erosion control on the Princeton and Wheeling soils.

Except for the rolling Princeton soils and the sloping to steep Wheeling soil areas, soils of this association can be intensively row cropped without damage to the soil. Corn and soybeans are grown on the bottom soils because they can be planted in late spring and harvested early in the fall when floods are less likely to occur. Small grains and meadow crops are included in the rotation on the more rolling Princeton and Wheeling soil areas.

Surface drains and ditches as well as tile are used in the wet areas to overcome the problem of excess wetness.

Association 5

Markland-Henshaw-Uniontown Association: Deep, well drained, moderately well drained and somewhat poorly drained nearly level to steep lacustrine soils.

This is the smallest soil association in Perry County and occupies about 5 per cent of the land area. It occurs on terraces along the lower valleys of streams and at the conjunction of the streams with the Ohio River. Small acreages of these soils occur in Association 3.

Markland is the major series in this association and comprise about 44 per cent of the association. These soils are moderately dark colored, deep and moderately well to well drained. They are developed in calcareous lacustrine stratified silty clay and clay with thin strata of silty clay loam. They occur on strongly sloping and very steep escarpments along the major streams that flow to the Ohio River and on gently sloping areas in the upper valleys of Anderson River and Sulphur Fork Creek.

The Henshaw soils make up about 30 per cent of this association. They are light colored, deep, somewhat poorly drained and are developed in silts and medium to moderately fine textured lacustrine material underlain with stratified deposits. They occur on nearly level to gently

sloping terraces along the lower valleys of streams and at the conjunction of the stream with the Ohio River.

The Uniontown soils make up about 20 per cent of this association. They are moderately dark colored, deep and well drained to moderately well drained. They are developed in silts and medium to moderately fine textured lacustrine material underlain with stratified deposits. They occur on nearly level to sloping terraces.

The McGary soils make up about 5 per cent of this association. They are light to moderately dark colored, deep and somewhat poorly drained. They are developed in calcareous lacustrine stratified silty clay and clay with some strata of silty clay loam. These nearly level to gently sloping terrace soils are located in the upper valleys of Anderson River, Sulphur Fork Creek and Middle Fork Creek.

Included are minor areas of Patton soils which make up about 1 per cent of the association. They are dark colored, deep and very poorly drained. They occur in small depressional areas.

The major management problems of these soils are erosion control on the Markland and Uniontown soils, and drainage on Henshaw, McGary and Patton soils.

About half of the soils of this association are used for cultivated crops or pasture. These areas which are cropped are nearly level to sloping. The remainder of the area is severely eroded or steep and is either idle or in forest. Areas being cropped produce moderate to high yields when good management practices are used and lime and fertilizers are applied according to the soil and crop needs. Corn, soybeans, wheat and meadow crops are well suited. Alfalfa does well on the better drained soils, but is not adapted to the somewhat poorly drained soils.

Most of the farms where these soils occur are general livestock farms. The crops produced are usually fed to livestock produced on the land.

Literature Cited

1. Soil Survey Staff. 1951. Soil Survey Manual. U. S. Department of Agricultural Handbook No. 18., 503 pp.
2. Robbins, John M. Jr. and Armin R. Grunewald. "Soil Survey Report for Perry County, Indiana" in process.

Characteristics and Formation of Plinthite On Maui Island, Hawaii

Carl W. Guernsey, University of Illinois

Introduction

The tropical rain forest of Winward Haleakala mountain on Maui Island, Hawaii, has a geologic and climatic setting distinctly different from any in the continental United States (1, 2). Weathering has been so intense here that the major soil forming factors are fully expressed in the morphology of the soil.

One of the more striking characteristics of the soils is the widespread incidence of indurated plinthite in the soil profile. Plinthite, as used herein, has been variously referred to as ironstone or laterite (3, 4). The name is derived from the Greek word **plinthos,** meaning brick. In nature it occurs in a hard state, or a soft state that will usually harden if exposed to drying conditions.

While there are conflicting names and theories of formation for this material there is general agreement that plinthite is high in iron oxides and aluminum, low in organic matter and silica, and that it occurs in a matrix of highly weathered material.

This study concerns an area located on windward Haleakala mountain at elevation of 2,300 to 5,300 feet with annual rainfall of 200 to 400 inches. The land surface has an overall seaward slope of 10 to 15 percent. Topography consists of sloping interfluves, ⅛ to ½ mile wide, separated by drainages and gulches deeply incised into basalt bedrock. While the character of the landscape is dominated by the basalt, thin deposits of volcanic ash are detectable in the soil profile in the wind shadows of steep slopes and in depressions.

Previous Investigations

The Hawaiian Planter's Record of September and October, 1909 contains the first recorded reference to distinctive features of the soils of this area. Dr. H. L. Lyons, working under the auspices of the Experiment Station of the Hawaiian Sugar Planters Association, made a detailed field study of the forest disease in the area, and evaluated several possible causative agents (5, 6).

The disease involved the dying out of large tracts of trees, and potential denuding of this water shed which was so vital as a source of irrigation water for sugar cane production. As reported by Dr. Lyons, apparently healthy trees sickened and died in a matter of weeks. This condition was most pronounced on the gently sloping interfluves; decreasing rapidly as the slopes became steeper. Few trees appeared to be affected on areas with slopes over 100 percent. Dr. Lyons further reports that the precise limitation of the disease by topographic features is most striking. In his words "One may travel up an interfluve for a couple of miles through a recently dead forest, but if he turns

at any point toward the gulch he will come upon healthy trees at the crest of the steep slope near the gulch."

Possible causal agents investigated were parasitic fungi, insects, and harmful chemicals in the soil. Fungi were ruled out because so few could be found in the area, the disease seemed so closely controlled by topography, and that the same constitutional problems were produced in totally unrelated species of plants. Insects were also ruled out because of the small number present.

Chemical agents in the soil thus remained the most probable cause of the disease. The fact that below-ground portions of roots of diseased trees had turned a deep purple or black, and died, while above-ground brace roots were still natural functional tissue seemed indicative of chemical activity in the soil. In addition an oily appearing film was observed on the surface of standing water in the area, and attributed to soluble iron salts leached from the soil. It was also noted that hydrogen sulfide odors permeated the area.

From these observations it was hypothesized that with these soils high in ferric iron, sulfates, and organic matter, the high rainfall and stagnant water effectively excluded oxygen from the soil; thus inducing fermentation by anaerobic bacteria. This fermentation liberated toxic hydrogen sulfide which further acted to reduce ferric iron to ferrous iron which is also toxic. Chemical analyses published in the Hawaiian Planter's Record show a ferrous oxide content of 5.75 percent which is normally considered a prohibitive level for plant growth.

Recent Investigations

Since 1909, foresters of the Division of Land and Natural Resources, and irrigation engineers of the East Maui Irrigation Company have had a continuing interest in this Maui forest disease because of its potential effect on hydraulic characteristics of the watershed. However, the first known reference to the problem by soil scientists is contained in the soil survey of the Territory of Hawaii, published in 1955 (7). In this survey the author made note of the still active forest disease, and also recorded the first known observations of an ironstone sheet in certain soils of the rain forest area. These observations are fully confirmed in the current soil survey.

In the 1955 soil survey the observation was made that the ironstone sheet appeared to form at any point in the soil profile where very porous material overlay relatively less permeable substrata. However, recent observations indicate a great probability that the less permeable material overlay material of relatively high permeability.

Investigations made early in 1964 included the preparation of profile descriptions of representative soil types in the area. Descriptions of two such soil types are included below to illustrate the morphology of soils containing indurated plinthite as an ironstone sheet.

Amalu peaty clay
Elevation—4,200 feet
Rainfall—350 inches annually
Slope—8% Northeast

Horizon	Depth	Description
01	8-0 ″	Black (5YR2/1) fibrous peat with matted roots; pH 3.9.
Ag	0-8 ″	Mottled gray (10YR5/1) and dark gray (10YR4/1) clay which is massive but can be broken to weak angular blocky structure; firm, sticky, and plastic; many roots; common fine pores; slightly smeary under pressure; has rubbery feel; abrupt boundary; pH 4.2.
B2ir m	8-8¼″	Indurated plinthite in solid horizontal phase.
B3ir	8¼-32+″	Soft plinthite with fragments of hard plinthite in matrix of highly weathered basalt; halloysite and gibbsite in seams; many large pores.

Koolau silty clay
Elevation—2,500 feet
Rainfall—225 inches annually
Slope—7% Northeast

Horizon	Depth	Description
A1	0-3″	Dark grayish brown (2.5Y4/2) silty clay with few fine faint mottles of grayish brown (2.5Y5/2) and dark brown (10YR4/3); weak fine subangular blocky structure; friable, sticky, plastic, and slightly smeary; many roots, few fine pores; pH 4.0; clear boundary.
Ag	3-13″	Gray (2.5Y5/1) clay with common distinct mottles of olive brown (10YR5/4); massive; firm, very sticky and very plastic; few fine roots; common very fine, and few coarse pores; large pores have well developed metallic coatings on interior walls; has rubbery feel; pH 5.0; clear boundary.
B21g	13-19″	Light brownish gray (2.5Y6/2) and pale brown (10YR6/3) clay with few fine faint mottles of dark brown (7.5YR4/4); weak fine blocky structure; sticky and plastic; few roots; common fine pores; gritty feel due to plinthite nodules; pH 4.7; abrupt boundary.
B22ir m	19-19½″	Red, gray, and brown indurated plinthite in solid horizontal phase; abrupt boundary.
B3	19½-30″	Reddish yellow (7.5YR6/6) silty clay with many prominent mottles of yellowish red (5YR4/6), brown (7.5YR4/4), and black (N2/0); massive; common plinthite as segregated sharp edged particles, and as thin coatings on saprolite; plinthite content appears to decrease with depth; many medium and large pores; gradual boundary.
C	30-36+″	Gray, yellow, and black soft rock encasing hard cores (saprolite); vesicular.

All colors are for moist soil. Terminology according to Soil Survey Manual (8).

This indurated plinthite sheet is a dominating soil characteristic on slopes below 25 percent in areas with annual rainfall above 150 inches. At the minimal rainfall it commonly forms at depths of 18 to 24 inches below ground surface, while at rainfall above 300 inches it is seldom more than 15 inches below ground surface. When viewed through a 14X hand lens it can be seen that the horizons below the plinthite layer have significantly more medium and large pores than the upper horizons. The indurated plinthite (Bir m horizon) is characteristically less than ½ inch thick; can be penetrated by a spade only with difficulty; is exrtmeley dense; and serves as a complete barrier to air and water movement except where fractured.

Theory of Formation

In this area of high rainfall, low evaporation, and gentle slopes the soil surface is saturated at all times. This effectively excludes air from the soil and makes a favorable environment for production of hydrogen sulfide through anaerobic fermentation. The hydrogen sulfide reduces ferric iron to ferrous iron which is not only toxic, but mobile. Ferrous iron gradually migrates downward in percolating water until it approaches the interface between saturated surface material and more porous material below. At this interface re-oxidation and precipitation of the iron takes place as the downward moving solution momentarily resists entrance into larger voids of the material below, and comes into contact with oxygen diffusing upward through the porous basalt. Over long periods of time a solid sheet of precipitated iron has thus developed into indurated plinthite. It is suggested that the theory of formation advanced above is very similar to Bartelli's theory for the formation of Beta horizons in glacial outwash soils (9).

Literature Cited

1. Thorpe, J. 1941. Geographic Setting and Climate of the Hawaiian Islands. Climate and Man, U.S.D.A. Yearbook of Agriculture. pp. 225-226.
2. Stearns, Harold T, and Gordon A. Macdonald. 1942. Geology and Ground Water Resources of the Island of Maui, Hawaii. Bulletin No. 7, Division of Hydrography, Territory of Hawaii.
3. Alexander, L. T. and J. G. Cady. 1962. Genesis and Hardening of Laterite in Soils. Technical Bulletin 1282, U.S.D.A. Soil Conservation Service. 99 pp.
4. Sivarajasingham, S., L. T. Alexander, J. G. Cady, and M. G. Cline. 1962. Laterite. Advances in Agronomy. Volume 14.
5. The Hawaiian Planter's Record, Vol. 1, No. 3, September 1909. Experiment Station of the Hawaiian Sugar Planters Association.
6. The Hawaiian Planter's Record, Vol. 1, No. 4, October 1909. Experiment Station of the Hawaiian Sugar Planters Association.
7. Soil Survey —Territory of Hawaii. Series 1939, No. 5, U.S.D.A. Soil Conservation Service cooperation with the Hawaii Agricultural Experiment Station. pp. 387-389, 421-424.
8. Soil Survey Manual. 1951. U. S. Department of Agriculture Handbook No. 18.
9. HBaretlli, L. J., and R. T. Odell. 1960. Field Studies of a Clay-Enriched Horizon in the Lowest Part of the Solum of Some Brunizem and Gray-Brown Podzolic Soils in Illinois. Soil Sci. Soc. Am. Proc. **24**:388-390.

Determination of the Gross Gamma Radioactivity of Indiana Soils by Large Volume Liquid Scintillation Counting

PAUL L. ZIEMER and JOHN E. CHRISTIAN, Purdue University

Introduction

A portion of the normal background radiation dose to which man is exposed is due to radioactivity in the earth's crust. This radioactivity is due in part to the presence of natural radioactive substances of the uranium and thorium series and in some cases carbon-14 and potassium-40 (2). Atmospheric testing of nuclear weapons over the past decade has resulted in the deposition of fallout fission products in soils. Of particular concern in the latter case has been the possible entrance of these radioactive materials into the food cycle and eventually into man.

Previous studies (1) have shown that typical Indiana soils (Plainfield sand, Clearmont silt loam, Crosby silt loam and Zanesville silt loam) contain an average of 2.73 x 10^{-3}g uranium per kg soil, 6.2 x 10^{-3} g thorium per kg soil, and 14.0 g potassium per kg soil (of which about 1.7 x 10^{-3} g is the potassium-40 isotope). In addition to these natural constituents, the long-lived gamma emitters cesium-137, ruthenium-106, and cerium-144 have been identified in amounts of the order of 10^{-10} to 10^{-9} curies per kg (1).

The increased use of power reactors with the potential of accidental release of radionuclides to the environment, together with the possibility of future resumption of nuclear weapons testing, suggest that it would be prudent to develop methods for rapidly measuring large numbers of soil samples for gross activity. This would be particularly important in our nation's farmlands and agricultural areas. Furthermore, it is desirable to know the extent of natural radioactivity in soils so as to provide a reference point for evaluating increases.

In this study, samples of Indiana soil, collected prior to resumption of weapons testing in 1961, were examined for gross gamma radioactivity by means of a large volume liquid scintillation counter. The technique is both rapid and sensitive, and would lend itself quite well to a large scale monitoring program.

Method of Sample Collection

The samples studied represented soils submitted from 2153 farm fields in 63 counties throughout the State of Indiana.[1] Samples were collected by the individual farmers who were instructed to sample as follows:

1. Use a sampling tube, auger, or spade.
2. Get 10 or more equal sized cores or slices from the surface to plow depth (6-8 inches) except permanent pastures (2-3 inches).

[1] The assistance of R. K. Stivers of the Purdue Agronomy Department in supplying soil samples from the Soil Testing Laboratory is gratefully acknowledged.

3. Place cores or slices in a clean pail and mix thoroughly.
4. Spread mixture on a clean paper to air dry. Do not heat.
5. Fill sample carton (supplied) with the air-dried mixture.
6. Number the sample and mark its location on the field map.

The samples from each field, which averaged about 200 g each, were pooled by counties and thoroughly mixed. From the mixed sample, a representative 1000 gram portion was taken for the gross activity determination.

Instrumentation

The 1000-gram samples from the various counties were placed in quart size ice cream cartons[2] and introduced into the 8 inch long by 4 inch diameter sample chamber of the Purdue Small Animal Counter (PUSAC). This counter, a large volume liquid scintillation counter, has been described in detail by Dunavant and Christian (3). Briefly, PUSAC was a 4 pi system consisting of an annular tank 8 inches long and 16 inches in diameter with a central sample chamber. The tank was filled with approximately 23 liters of a scintillator solution (p-terphenyl and POPOP in toluene). Four 5-inch Dumont 6364 photomultipliers were mounted symetrically about one end of the tank. Shielding was accomplished by means of a cylindrical rolled iron shield 5 inches thick completely surrounding the scintillator tank.

A voltage distribution panel permitted separate adjustment of the individual high voltages on each photo tube. The tube anodes were connected in parallel and the output pulse fed to a preamplifier, an amplifier, a single channel analyzer, and a scaler respectively.

The instrument was operated in the integral counting mode with the base discriminator set at zero and the gain at 1/16. These settings permitted spanning essentially the full energy spectrum giving maximum counting efficiency.

All samples were counted for 4 minutes (four 1-minute counts) preceded and followed by two 1-minutes background counts. The backgrounds were obtained by using a mock soil blank of pure sugar in the chamber so as to eliminate any need to consider background reduction corrections due to sample mass.

For purposes of calibration, a vial containing 1 ml of a 920 gamma/sec/ml standard cesium-137 solution[3] was imbedded in the center of one of the cylindrical cartons filled with pure sugar as an absorbing medium. Gross gamma counting efficiency was determined by comparing the observed count rate with the known disintegration rate of the standard. For the system as described, the counting efficiency for gammas was 33.4%.

Results and Discussion

Results for the samples studied are tabulated in Table 1 by counties. The average gross gamma activity for all counties was 4.6 picocuries per gram. The highest individual sample observed was 5.9

[2] Standard Package Corporation, Serial FC-1.

[3] Prepared from Nuclear Chicago Model RS-137 radioactive standard solution.

TABLE 1

Gross Gamma Activity of Indiana Soils

County	Sample Wt. (grams	Net Counts/min	pc/g
Adams	1000.00	4174	5.6
Allen	1012.50	3869	5.2
Bartholomew	1055.70	3039	3.9
Benton	971.37	3512	4.9
Blackford	1017.60	4218	5.6
Carroll	1111.22	3988	4.8
Cass	1000.00	3114	4.2
Clinton	1033.20	4044	5.3
Davies	1000.00	2673	3.6
Decatur	1034.00	3751	4.9
Dekalb	1000.00	3473	4.7
Delaware	1057-60	3965	5.1
Elkhart	1000.00	2679	3.6
Fayette	988.20	3675	5.0
Floyd	1000.00	3635	5.0
Fountain	1003.90	3879	5.2
Franklin	1000.00	3827	5.2
Fulton	1013.20	1974	2.6
Gibson	1000.00	3997	5.4
Grant	910.00	3908	5.8
Hamilton	1056.90	3565	4.5
Hancock	1035.70	3764	4.9
Henry	1000.00	3723	5.0
Howard	1124.52	4566	5.5
Huntington	1046.90	3972	5.1
Jackson	1038.00	3714	4.8
Jasper	1053.90	1970	2.5
Jay	1030.40	4510	5.9
Johnson	1000.00	3542	4.8
Knox	1000.00	2777	3.8
Kosciusko	1049.80	2483	3.2
Lake	1000.00	3408	4.6
LaPorte	1022.80	2571	3.4
Lawrence	1000.00	3703	5.0
Madison	1015.40	4105	5.5
Marion	1000.00	3552	4.8
Marshall	1123.60	2700	3.2
Miami	1044.40	3126	4.0
Montgomery	1000.00	3084	4.2
Morgan	1000.00	3464	4.7
Newton	1000.00	2668	3.6
Nobel	994.40	2738	3.7
Parke	1045.20	3717	4.8
Porter	1021.70	3296	4.4
Posey	1052.90	3925	5.0
Pulaski	1041.60	1906	2.5

County	Sample Wt. (grams	Net Counts/min	pc/g
Putnam	1021.90	3841	5.1
Randolph	1032.50	4248	5.5
Ripley	1000.00	3699	5.0
Rush	1041.10	3879	5.0
Shelby	1005.50	3572	4.8
Steuben	1000.00	2049	2.8
Sullivan	1045.80	3730	4.8
Tippecanoe	1077.95	3357	4.2
Tipton	1102.88	4325	5.3
Vanderburg	1000.00	3782	5.1
Vermillion	1052.00	3335	4.3
Wabash	947.70	3444	4.9
Warren	1000.00	3898	5.3
Wayne	998.90	3600	4.9
Wells	1000.00	4157	5.6
White	1113.64	2778	3.4
Whitley	1000.00	3480	4.7
		Average:	4.6

picocuries per gram for Jay County, while the lowest was 2.5 picocuries per gram for both Jasper and Pulaski Counties.

Based on the statistical counting errors for four-minute sample counts and four-minute backgrounds, the precision of the method was calculated to be ± 0.08 picocuries per gram.

The technique of determining the gross radioactivity in environmental samples by large volume liquid scintillation counting is both rapid and sensitive. Sample handling and processing is minimized, and no chemical treatment or manipulation is required. The method should prove useful for large scale environmental monitoring programs where rapid evaluation of gross activity is required.

Literature Cited

1. Akalan, Ilhan, and J. L. White. 1963. Natural and Fission-produced Radioactivity in Four Indiana Soils. Proc. Ind. Acad. Sci. **72**:325-329.
2. Cowan, F. P. 1959. Natural Radioactive Background. Radiation Hygiene Handbook, Hanson Blatz, Editor, McGraw-Hill Book Company, Inc., New York: 4-1 - 4-18.
3. Dunavant, B. G. and J. E. Christian. 1960. A Large Volume 4 pi Liquid Scintillation Detector. Int. J. Appl. Radiation Isotopes **8**: 223-227.

Gross Gamma Radioactivity in Indiana Precipitation

P. L. Ziemer,[1] L. A. Schaal,[2,3] J. E. Newman, C. L. Rhykerd,[2] and J. E. Christian,[1] Purdue University

Introduction

Worldwide sampling of water, soil, air and precipitation has shown that long term stratospheric fallout levels of strontium-90 and cesium-137 are closely correlated with the distribution of high velocity westerly winds and associated precipitation (1). These relationships focus particular attention on the geographical areas of the mid-latitudes such as the eastern half of the continental U. S. and western Europe. In such areas long term atmospheric fallout from post weapons tests is believed to be concentrated in two major ways: first through the amount of precipitation over a long period of years, and second, by the resulting runoff from precipitation. The principle gamma emitters that have been identified in fallout are zirconium-95, niobium-95, iodine-131, cesium-137, barium-140, and lanthanum-140. Knowledge of how to estimate and locate high concentrations of long-lived isotope fallout accumulation is an important consideration in agricultural production and marketing procedures.

The Public Health Service (4) has pointed out the growing need for more federal, state, and municipal agencies to assess the radioactivity level in environmental samples such as air, food, vegetation, milk, and water. The Public Health Service has further stated that in most cases it is desired to measure first the gross activity of the sample and then, where indicated, the activity of specific nuclides. Such measurement of gross activity at various installations throughout the country is presently complicated by a number of factors such as choice of standards, techniques of sample preparation, and type of instrument used for counting.

The determination of fallout activity in precipitation is presently carried out under the auspices of the U. S. Public Health Service Radiation Surveillance Network (5, 6). Precipitation is collected at each station using funnels with collection areas of 0.4m.^{2} One-half liter of the precipitation is evaporated to dryness and the residue sent to a central laboratory for gross beta analysis for fission products. This method has certain disadvantages such as the time involved in carrying out the evaporation and the possible loss of volatile nuclides during evaporation.

This paper describes a rapid and sensitive method for determining the gross activity of precipitation samples by the method of large-volume liquid scintillation counting.

---

[1] Bionucleonics Department, School of Pharmacy and Pharmacal Sciences.

[2] Agronomy Department, Agricultural Experiment Station.

[3] Weather Bureau, U. S. Department of Commerce.

Sample Collection and Processing

Commencing April 1, 1962, and continuing through March, 1963, precipitation catches in excess of 1 inch of water per 24 hours were collected from 29 official U. S. Weather Bureau standard 8 inch gages, geographically distributed over Indiana. From April, 1963, through March, 1964 sampling was continued at 14 of the stations. A total of 278 samples were collected over the 2 year period. Collection as indicated provided samples of approximately 1 liter in volume. Catches were transferred directly to 1 liter polyethylene bottles at the weather stations and mailed to the Bionucleonics laboratories at Purdue for the activity determinations. The only sample processing prior to determining the gross activity was a measurement of the volume. If the volume slightly exceeded 1 liter, the excess was discarded. If the volume was less than 1 liter, activity-free distilled water was added to bring the volume up to 1 liter. Finally, the exterior of each bottle was washed with distilled water so as to remove any residual surface contamination which might have accumulated.

Instrumentation and Counting Techniques

All samples were counted directly in the bottles in which they were received. These polyethylene containers were introduced into the 8 inch long by 4 inch diameter sample chamber of the Purdue Small Animal Counter (PUSAC). Dunavant and Christian (2) have described this large volume liquid scintillation counter in detail. The counter was a 4 pi system consisting of an 8 inch long by 16 inch diameter annular tank with central sample chamber. The tank was filled with approximately 23 liters of a scintillator solution (p-terphenyl and POPOP in toluene). Four 5-inch Dumont type 6364 photomultiphers were mounted at one end of the tank. Shielding was accomplished by means of a cylindrical rolled iron shield 5 inches thick. The output pulses from the photomultipliers were fed to a preamplifier, an amplifier, a single channel analyzer, and a scaler.

The instrument was operated in the integral counting mode for maximum sensitivity. Each sample was counted for 10 minutes (three 200-second counts) preceded by and followed by background counts. Backgrounds were determined with a 1 liter sample of pure distilled water in the counting well so that no correction was necessary for background depression from the sample mass.

Samples were counted approximately 10 days after collection depending on the time interval between collection and receipt by our laboratory. No attempt was made to correct for decay during this interval of short lived materials.

Instrument Calibration

Most work on gross measurements of fallout reported in the literature is given in terms of gross beta activity. It would be just as convenient to report gross gamma activity if an appropriate means of calibration is established.

For a mixture of fission products, a complex decay scheme results. A beta particle is liberated in each disintegration, but gamma

ray photons are produced in only about one-half the fission product disintegrations, the fraction varying somewhat with time after explosion (3). Furthermore, the mean energy of the gamma photons does not remain constant with time. Thus, a precise calibration for fission products is essentially impossible for either the betas or the gammas in a fission product mixture. However, for periods of practical interest, the mean energy of the gamma ray photons may be taken as essentially constant at about 0.7 Mev. (3).

Cesium-137 was chosen as the calibration standard for the gross gamma measurements because its gamma energy (0.662 Mev) is very close to the average gamma energy for mixed fission products Also, cesium-137 is itself one of the important long-lived fission products and offers the additional advantage of having a simple and well-known decay scheme. For purposes of the gross gamma measurements, a curie of gamma activity was defined as that activity which resulted in 3.7×10^{10} gamma photons per second.

The calibration standard was prepared by placing 1 ml of a 920 gamma/sec/ml standard solution[1] in one of the polyethylene bottles and diluting to 1 liter with distilled water containing 0.1 g/l $CsNO_3$ as a carrier. Thus the standard was identical to the precipitation samples with respect to physical size, volume, density, and container material. Using this standard, the counting efficiency for the system was found to be 28.2%.

Results and Discussion

The deposition of radioactivity in an area may be determined from the concentration of activity in the precipitation samples as follows:

$$D = \frac{CP}{1000}$$

where D is the deposition in nanocuries per square meter, C is the concentration in picocuries/liter, and P is the depth of the precipitation in mm. The individual values of deposition and depth of precipitation were totaled for each month, and the average concentration for the month, $\overline{C}$, was determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

Table 1 summarizes the average yearly deposition and concentration values for each of the 29 stations for the period from April, 1962, through March, 1963. Deposition and concentration values for the 14 stations participating in the April, 1963 to March, 1964 collection period are also listed in Table 1.

The highest average monthly deposition over the two year period was 271.6 nc/m^2 which occurred in March, 1963 at Franklin, Indiana. Franklin also showed the highest yearly total deposition of 439.5 nc/m^2 for the period April, 1962 to March, 1963. This high deposition is a reflection of the amount of rainfall occurring in Franklin whose 13 samples represented 528.6 mm of water. The highest average monthly

[1] Prepared from Nuclear Chicago Model RS-137 radioactive standard solution.

TABLE 1

Total Deposition and Average Concentration of Gamma Radioactivity in Indiana Precipitation April, 1962, to March, 1964

Station Number	Location	April, 1962 — March, 1963				April, 1963—March, 1964			
		No. Samples	Depth of Prec. (mm)	Total* Deposition	Ave. + Conc.	No. Samples	Depth of Prec. (mm)	Total* Deposition	Ave. + Conc.
1.	Portage	3	88.9	100.2	1125				
2.	Wanatah	6	205.5	50.2	244	6	231.1	166.6	721
3.	South Bend	16	347.0	211.1	608	3	110.2	28.8	261
4.	Kendallville	5	132.8	78.6	592				
5.	Collegeville	1	41.1	34.3	835				
6.	Culver	4	126.5	98.2	776				
7.	Warsaw	4	136.9	130.9	956	5	198.9	165.2	831
8.	Fort Wayne	6	157.5	100.5	638	3	71.6	46.9	655
9.	Lafayette	11	402.6	247.1	614				
10.	Kokomo	4	134.1	87.0	649				
11.	Upland	9	329.7	292.2	886	3	108.2	89.6	828
12.	Farmland	10	289.5	197.9	684	6	215.7	176.3	817
13.	Crawfordsville	12	394.7	171.2	434				
14.	Whitestown	5	190.5	95.4	501				
15.	Knightstown	6	265.4	227.3	856	4	131.8	61.7	468
16.	Terre Haute	10	332.2	214.5	646				
17.	Spencer	5	240.0	139.9	583	1	26.4	9.9	375
18.	Franklin	13	528.6	439.5	831	3	89.4	67.5	755
19.	Greensburg	11	316.9	195.2	616	3	100.8	120.5	1195
20.	Edwardsport	8	268.7	270.7	1007				
21.	Bedford	9	413.8	269.4	651	4	93.5	106.7	1141
22.	Seymour	9	360.9	339.3	940				
23.	Owensville	3	112.0	140.4	1254				
24.	Evansville	12	406.4	224.8	553	4	132.3	112.9	853
25.	Tell City	10	352.0	239.7	681				
26.	Dubois	5	141.0	92.6	657	3	123.4	124.4	1009
27.	Henryville	7	274.1	289.6	1057				
28.	Clarksville	10	349.7	194.3	556	3	110.2	136.8	1241
29.	Madison	13	418.6	292.3	698				

* (nanocuries per square meter)

\+ (picocuries per liter)

concentrations observed were 2084 pc/1 for a rainwater sample collected in May, 1962 at Owensville and 3838 pc/1 for a snow sample collected in January, 1963 at South Bend.

The precision of the counting method, based on three 200-second sample counts and two 200-second background counts was ± 45 pc/1.

Values for the maximum permissible concentration (MPC) for the various fission products in drinking water have been established by the National Committee on Radiation Protection. These values range from 2000 picocuries/liter for iodine-131 to 20,000 picocuries/liter for lanthanum-140 based on continuous consumption of such water for periods up to a year. Levels of gamma fallout radioactivity in Indiana precipitation were thus well below MPC values during the period April, 1962 through March, 1964.

Literature Cited

1. Alexander, L. T., et al., 1961. Strontium-90 on the Earth's Surface Summary and Interpretation of Worldwide Soil Sampling Programs. U. S. Atomic Energy Commission, Office of Technical Information TID-6567.
2. Dunavant, B. G., and J. E. Christian. 1960. A Large-Volume 4 Pi Liquid Scintillation Detector. Int. J. Appl. Radiation Isotopes 8, 223-227.
3. Knapp, H. A., 1959. Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, Eighty-Sixth Congress, First Session on Fallout from Nuclear Weapons Tests. pp 1969-1976.
4. U. S. Department of Health, Education, and Welfare, 1960. Radiological Health Data, No. 6, 54.
5. Ibid., 1962, 3, No. 1, 7.
6. Ibid., 1962, 3, No. 4, 105.

ZOOLOGY

Chairman: ROBERT H. COOPER, Ball State Teachers' College

WILLIAM EBERLY, Manchester College, was elected chairman for 1965

ABSTRACTS

Birds Eggs in the Gorby Collection. J. HILL HAMON, Indiana State College.—Indiana State College recently acquired the Gorby Collection, a large natural collection, from Franklin College, Indiana. It was assembled by S. S. Gorby who was State Geologist of Indiana from 1889-1894. Included in the collection is an outstanding assemblage of invertebrate fossils including a number of type specimens, a large number of invertebrate neospecies, and a small cabinet of bird eggs. Nineteen orders of birds are represented by 758 eggs of 366 species. Items of particular interest include eggs of the passenger pigeon, *Ectopistes migratorius*, the whooping crane, *Grus americana*, and a number of European species. There are no data recorded on this collection.

Minimum Numbers of Histocompatibility Factors Among Eurycea bislineata and Eurycea lucifuga.[1] JOHN T. BURNS, Wabash College.—One variant histocompatibility factor between two individuals is enough to lead to rejection of the skin of the individual with the factor by the one lacking it. On the assumption that salamanders occupying limited areas of a stream or those associated with caves might be relatively closely related, skin grafts were made among all members of sets of *Eurycea bislineata* and of *Eurycea lucifuga*, the latter of which frequent caves, to see if any two or more animals possessed a genetic identity which would allow for graft acceptance. Thirty *E. bislineata* (n) were collected within a 27 m length of stream and were multiply grafted until each animal had been challenged by the skin of every other animal (n-1). In all, 870 homografts, 30 (n-1), plus 30 autografts were planted but only the autografts were accepted. Theoretically by excluding homozygotes and assuming a single histocompatibility locus, one could account for the mutual rejections among animals sharing a minimum of 9 multiple alleles. The selecting procedure favors homogeneity rather than heterogeneity and also favors relatively frequent expression of homozygosity. Thus, in view of the size of the sample and the number of grafts, the data strongly suggest that in *E. bislineata* the minimum number of factors is greater than nine. Samples of *E. lucifuga* are smaller but the pattern of rejection is the same as for *E. bislineata*, there being minimal values of 5 factors for 7 animals from May's Cave and 6 factors for 11 animals from Ray's Cave. It would seem that conditions which might have allowed for selection have not operated insofar as histocompatibility genes are concerned.

Distribution of Opposing Valves of Dinocardium robustum (Mollusca) on a Texas Beach. CHARLES D. WISE, Ball State Teachers College, and LOUIS S. KORNICKER, U. S. National Museum.—Deposits of clam

1. Supported by NSF GE 1916 (URPP) and NIH GM 05619 to L. E. DeLanney.

shells on recent beaches, as well as in ancient sediments in the fossil record, often exhibit an excess of left over right valves or right over left valves. The occurrence is sometimes referred to as the left-right phenomenon. In an attempt to determine factors influencing this phenomenon, valves of **Dinocardium robustum** were collected from the beach at Port Aransas, Texas through a period of 21 months. The differences in numbers of opposing valves were found to be significant for some of the months. Furthermore, for these same months, it was found that averages of valve length were greater than for those months without significant differences in numbers of opposing valves, suggesting a high energy surf requirement for separating opposing valves. Differences between opposing valves in weight, ornamentation, and fragility seemed not to be important factors in differences in their distribution. A definite seasonal pattern in occurrence of significant differences in number of opposing valves was not revealed by the study. Incidentally, it was found that boring snails attack left and right valves in equal numbers and seem to favor clams of small size.

New Findings for the Protozoan Halteria grandinella. HENRY TAMAR, Indiana State College.—Little research has been done on *Halteria grandinella* because of lack of an adequate culture method. A satisfactory culture method based on the house fly (*Musca domestica*) has now been devised. *Halteria grandinella* grown by this method were found to have a structure different in major features from that previously described. Earlier researchers are also in disagreement about major structural features of this species, and it thus appears possible that there may be varieties of *H. grandinella*. The locomotion of *H. grandinella* was also investigated, and a new escape movement, named rapid backward spiraling, was discovered. *H. grandinella* which swim into the surface of the liquid containing them burst there, probably because of the high energy present at a liquid surface (surface tension).

Tropical Medicine in the Caribbean—a Training Program of Great Value to Teacher of Parasitology. KENNETH D. BURNHAM, Ball State University—The Inter-American Fellowship Program, administered by Louisiana State University School of Medicine and financed by the National Institutes of Health, affords teachers of parasitology, bacteriology, and allied fields valuable and current information on diseases and health conditions in Latin America. The opportunity to meet with Latin-Americans engaged in parasitological research, access to acquire instructional materials, and some insight into problems of tropical medicine are also provided. Small groups are sent, at various times during the year, to either the Caribbean area (Puerto Rico, Trinidad, Venezuela, and Columbia) or to Mexico and Central America. The duration of the program is approximately ten weeks and *per diem* support and travel arrangements are provided. Some aspects of the conditions encountered in the Caribbean area and of the types of health problems likely to be found were described utilizing 2 $\times$ 2 colored slides.

Effect of Handling and of Pre-training of Chicks on a Subsequent Learning Task in the T-maze. W. C. GUNTHER, Valparaiso University.—Chicks hatched from eggs incubated at normal temperature were variously handled and pre-trained in a T-maze. Handling was accomplished by simply picking up each chick and returning it to its brooder at least once a day. The pre-training consisted of placing the chicks singly in a T-maze for varying lengths of time, from one minute to 20 minutes. Food was available at all times in both arms of the maze. After the training period the chicks were run for 22 trials in the maze, having to learn to find the correct food-well placed in one arm of the maze. The time in seconds that it took the chicks to find the correct food-well was used as a criterion of performance. When compared with unhandled and untrained birds, the handled and pre-trained chicks performed significantly better by groups: the latter also learned at a significantly faster rate. The optimal pre-training period under these conditions was found to be 10 minutes.

Soluble and Membrane-bound Trehalases in Insects.[1] ARNOLD E. S. GUSSIN and G. R. WYATT, Butler University and Yale University.—*Cecropia* flight muscle was homogenized in ice-cold polyvinylpyrrolidome containing 1mM EDTA and fractionated in the centrifuge; fractions were assayed for trehalase activity by a modification of the glucose oxidase technique. The specific activity of the enzyme was greater in the high speed fraction (105,000xg, 60 min) than in any other fraction. No activity was noted in the soluble supernatant. A similar experiment on larval midgut showed that trehalase was most activc in the high speed fraction; in this experiment, however, the supernatant also exhibited some activity.

The particulate flight muscle enzyme exhibited a pH optimum at 6.8 and a Km value of 3.6×10^{-3}M, while the corresponding values for the particulate larval midgut trehalase were 6.8 and 2.9 v 10^{-3}M. The soluble form of the midget enzyme, on the other hand had a pH optimum of 5.8 and a Km of 3.6×10^{-4}M. These latter values are similar to those obtained by several other workers for the soluble enzyme derived from whole insects. These workers were probably not aware of the existence of a particulate trehalase.

The particulate flight muscle enzyme was localized in the high speed or "sarcotubular" fraction of the cell. Cytochrome c oxidase assays showed this fraction to be virtually free of sarcosomes. Also, electron micrographs of the fraction illustrated that it was composed of small vesicles, tubules and particles, but that fibrils and sarcosomes were absent.

Current Taxonomic Status of the Blind Snakes, Families Typhlopidae and Leptotyphlopidae. JAMES C. LIST, Ball State Teachers College.—The six genera and 250 species of Blind Snakes have classically been arranged in two families. A proposal to erect a third family for one of the genera has met with various reactions. A more

[1]Supported by grant AI-01028 from the U.S.P.H.S. and a Postdoctoral Fellowship (A.E.S.G.).

recent proposal that the Typhlopidae be removed entirely from the suborder Ophidia has likewise been variously received.

A study of the skeletal anatomy of 33 species of the Blind Snakes leads me to (1) support the establishment of a third family, but to include four genera, (2) urge that the Blind Snakes be retained in the Ophidia, and (3) suggest changes in the interpretation of certain skeletal homologues.

The Follicle Stimulating Hormone Content of Chicken Anterior Pituitary Glands. FRANK J. ZELLER, Indiana University.—Evaluation of the anterior pituitary gonadotropins of laboratory and domestic animals has been the object of a large number of investigations. In mammals, particularly in the rat and mouse, the studies have become quite specific in attempting to distinguish between the content of the follicle stimulating hormone (FSH) and the luteinizing hormone under varying conditions. Recently, several studies have been made on the gonadotropic content of chicken pituitary glands utilizing newly hatched chicks as the assay animals. These assays, based upon increased testis weight or P^{32} uptake, measured total gonadotropin. The purpose of this report was to present a preliminary study on the use of the Steelman-Pohley assay method of determining specifically the FSH content of White Leghorn pituitary glands over a period of two hundred days. It was noted that from day 20 to day 100 the anterior pituitary glands of capons generally had a higher FSH content than did those of unoperated controls; but after this the control glands contained comparatively more FSH. In another observation, testosterone propionate was shown to increase the FSH content of capon pituitary glands.

Metamorphic Stasis in the Larval Amphibian after Cold Exposure. W. ANN REYNOLDS, Ball State Teachers College.—After exposure to 4°C for 7 or more days, metamorphic progress and growth were inhibited after rewarming in certain *Rana pipiens* larvae. Both normal animals and those treated with 1-thyroxine prior to and/or during cold exposure entered into stasis after rewarming. The observed stasis was terminated by thyroxine administration resulting in eventual completion of metamorphosis implying that the thyroid-pituitary axis is being affected by cold rather than individual tissues. Metamorphic stasis was reversed spontaneously in some instances and entirely failed to occur in approximately one-fourth of the cases which continued to metamorphose normally after rewarming. Certain animals treated with thyroxine in the cold bath, while failing to demonstrate any metamorphic advance at that temperature, metamorphosed precociously upon rewarming although no further hormone was administered suggesting that the hormone is being retained by the tissues.

Pituitary glands were removed from normally metamorphosing tadpoles and implanted behind the right eye in tadpoles whose metamorphosis had been inhibited by prior cold exposure. The majority of the pituitary recipients then began to metamorphose immediately and completed the process successfully, indicating that the animal's own

pituitary gland had been altered by cold exposure but that the thyroid gland was still capable of apparently normal function. (Supported by grant GM-10295 from the U.S.P.H.S.)

A Preliminary Study of the Littoral Fish Populations in a Northern Indiana Lake. CHARLES O. HATCHER and JAMES R. GAMMON, Earlham College and DePauw University.—A fourteen foot seine with a four centimeter mesh was utilized to seine two areas of the littoral zone of Dewart lake in north central Indiana. Areas were seined on alternate days beginning July 11, 1964 and ending July 24, 1964. *Labidesthes sicculus*, the northern brook silversides, outnumbered the total *Cyprinidae* 25:1 in the seine's catch. Young-of-the-year *L. sicculus* outnumbered one year and older *L. sicculus* 400:1. Largest young-of-the-year *L. sicculus* growth increment over a ten day period was one centimeter. Diurnal migration was studied and it was found that young of the year *L. sicculus* move in and out of the seining area in relation to light intensity and temperature. An increase of predator fish in the seining area at night is followed by a subsequent drop in the population of young of the year *L. sicculus*. The two seining areas yielded 2,750 *L. sicculus*, the population recovering from the seining pressure every 5 days. The population density of *L. sicculus* was found to be on the average of 1.2 fish per cubic meter.

The Distribution of Fishes in Putnam County, Indiana, and Vicinity[1]

JAMES R. GAMMON, DePauw University

This report summarizes a study of the distribution of fishes in an area of approximately 1000 square miles which includes all of Putnam County and parts of Clay, Parke, Montgomery, Boone, Hendricks and Morgan Counties. Collections of fish from four main streams, their tributaries and headwaters were made during 1962, 1963 and 1964. Included in the study was that part of Raccoon Creek north of the town of Mansfield (drainage basin area = 260 square miles), Mill Creek (D. B. A. = 290 sq. mi.) and Big Walnut Creek (D. B. A. = 360 sq. mi.) above their junction with each other, and Deer Creek (D. B. A. = 90 sq. mi.).

These streams are relatively unpolluted and receive major contributions of treated domestic wastes only from Greencastle and the State Penal Farm at Putnamville. A single instance of fish mortality due to oxygen depletion as the result of pollution was noted in June, 1964 on Deer Creek below the latter site. Most of the Mill Creek system has been altered by dredging and straightening, but only the extreme headwaters of the Big Walnut and Raccoon systems in Boone and Hendricks Counties have been similarly affected.

The streams flow from northeast to southwest through a geologically varied terrain. The northern and eastern portions, comprising about half of the entire study area, consist of Borden formations of fine sandstone and siltstone. Mansfield sandstone underlies the extreme western part. Between these lies a wedge of limestone covering most of the southern part and tapering toward the northwest. Total alkalinity and pH determinations were made at 22 scattered locations on November 1 and 8, 1963, near the end of a prolonged drought. Total alkalinity ranged from 210 ppm. to 315 ppm. and pH ranged from 7.9 to 9.1.

Fifty-six sites within the study area were visited a total of one hundred and eleven times. Fish were obtained primarily by means of ¼ inch mesh seines and a portable, battery-powered, A. C. electric shocking apparatus. The more common species were identified in the field. Others were preserved and identified in the laboratory using the keys of Gerking (1955) and Trautman (1957). A thorough description of each station is not possible because of space limitations, but a few of the more important characteristics appear in coded form after each of the stations listed in the Description of collection sites. The code letters correspond to the characteristics listed below.

A. pools large; 100 or more feet in length, depth to 4 feet

B. pools large, but shallow

[1]Supported in part by a grant from the Graduate Council, DePauw University.

C. pools small, depths to 3 feet
D. pools small and shallow
E. pools non-existent; a regular, shallow flow
F. pool bottom mostly sand and/or gravel
G. pool bottom mostly rubble and/or bedrock
H. pool bottom mostly mud, silt or clay
I. riffle bottom mostly sand and/or gravel
J. riffle bottom mostly rubble and/or bedrock
K. average gradient less than 5 feet per mile
L. average gradient 5 to 10 feet per mile
M. average gradient 10 to 15 feet per mile
N. average gradient 15 to 20 feet per mile
O. average gradient 20 to 30 feet per mile
P. average gradient 30 to 40 feet per mile

The collection sites are listed below according to the stream system. Those on the mainstreams are listed consecutively beginning with the station farthest downstream and proceeding toward the headwaters. Tributaries are then listed in a similar order.

Description of collection sites

Big Raccoon Creek system

1. Big Raccoon creek, sec. 8, T. 14 N., R. 6 W. A, F, J, L.
2. Big Raccoon Creek, sec. 33, T. 16 N., R. 5 W. B, G, J, L.
3. Big Raccoon Creek, sec. 5, T. 16 N., R. 4 W. A, F, I, L.
4. Big Raccoon Creek, sec. 17, T. 17 N., R. 3 W. B, G, I, L.
5. Rocky Fork Creek, sec. 11, T. 14 N., R. 6 W. D, F, I, O.
6. Little Rocky Fork Creek, sec. 22, T. 14 N., R. 6 W. D, F, I, P.
7. Byrd Branch, sec. 30, T. 16 N., R. 5 W. D, G, J, O.
8. Ramp Creek, main stem, sec. 27, T. 16 N., R. 5 W. E, I, M.
9. Ramp Creek, main stem, sec. 30, T. 16 N., R. 4 W. A, F, I, L.
10. Ramp Creek, south branch, sec. 33, T. 16 N., R. 4 W. D, G, J, P.
11. Ramp Creek, north branch, sec. 20, T. 16 N., R. 4 W. C, F, I, M.
12. Cornstalk Creek, secs. 14, 27 & 34, T. 17 N., R. 4 W. A, F, I, L.
13. Haw Creek, sec. 30, T. 17 N., R. 3 W. C, F, J, M.

Big Walnut Creek system

14. Big Walnut Creek, stc. 29, T. 13 N., R. 5 W. A, F, I, K.
15. Big Walnut Creek, sec. 11, T. 13 N., R. 5 W. A, F, I, K.
16. Big Walnut Creek, sec. 27, T. 14 N., R. 5 W. A, F, I, K.
17. Big Walnut Creek, sec. 19, T. 14 N., R. 4 W. B, F, I, K.
18. Big Walnut Creek, sec. 10, T. 14 N., R. 4 W. B, F, I, K.
19. Big Walnut Creek, sec. 18, T. 16 N., R. 2 W. B, G, J, L.
20. Johnson Branch, sec. 19, T. 13 N., R. 5 W. E, I, M.
21. Maiden Run, sec. 16, T. 13 N., R. 5 W. C, F, J, O.
22. Snake Creek, sec. 33, T. 14 N., R. 5 W. D, F, J, O.
23. Little Walnut Creek, sec. 23, T. 14 N., R. 5 W. A, F, I, L.
24. Little Walnut Creek, sec. 10, T. 14 N., R. 5 W. B, F, J, L.
25. Little Walnut Creek, sec. 34, T. 15 N., R. 5 W. D, F, I, M.
26. Long Branch, sec. 22, T. 14 N., R. 5 W. C, F, I, O.
27. Clear Creek, sec. 22, T. 15 N., R. 3 W. B, F, I, M.

28. Miller Creek, sec. 34, T. 15 N., R. 3 W. B, F, J, N.
29. Bledsoe Branch, sec. 24, T. 15 N., R. 4 W. E, J, P.
30. Plum Creek, sec. 20, T. 15 N., R. 3 W. D, F, I, M.
31. Ramp Run, sec. 21, T. 16 N., R. 2 W. D, F, I, M.
32. Big Walnut Creek, East Fork, sec. 9, T. 16 N., R. 2 W. B, F, I, M.
33. Big Walnut Creek, West Fork, sec. 5, T 16 N., R. 2 W. B, F, J, M.

Deer Creek system

34. Deer Creek, sec. 26, T. 13 N., R. 5 W. A, F, I, K.
35. Deer Creek, sec. 23, T. 13 N., R. 5 W. A, F, I, K.
36. Deer Creek, sec. 24, T. 13 N., R. 5 W. B, F, I, K.
37. Deer Creek, sec. 16, T. 13 N., R. 4 W. A, F, G, L.
38. Deer Creek, sec. 10, T. 13 N., R. 4 W. B, F, J, M.
39. Deer Creek, sec. 2, T. 13 N., R. 4 W. B, F, I, M.
40. Leatherwood Creek, sec. 25, T. 13 N., R. 5 W. D, G, J, O.
41. Deweese Branch, sec. 5, T. 13 N., R. 4 W . D, F, I, M.
42. Upper Limestone Creek, sec. 12, T. 13 N., R. 4 W. C, F, J, P.
43. Little Deer Creek, sec. 32, T. 14 N., R. 3 W. D, F, I, O.

Mill Creek System

44. Mill Creek, sec. 13, T. 12 N., R. 5 W. A, H, K.
45. Cataract Lake, sec. 19, T. 12 N., R. 4 W.
46. Mill Creek, sec. 35, T. 12 N., R. 4 W. Between upper and lower Cataract Falls, A, F, J.
47. Mill Creek, sec. 2, T. 12 N., R. 3 W. B, F, I, K.
48. Mill Creek, sec. 36, T. 13 N., R. 3 W. B, F, I, K.
49. Mill Creek, sec. 30, T. 13 N., R. 2 W. B, F, I, K.
50. Mill Creek, sec. 35, T. 15 N., R. 2 W. D, F, I, L.
51. Ferguson Branch, sec. 2, T. 12 N., R. 4 W. C, F, J, P.
52. Vermillion Branch, sec. 35, T. 13 N., R. 3 W. D, H, I, M.
53. Lake Ditch, sec. 21, T. 13 N., R. 2 W. E, H, K.
54. Mud Creek, sec. 2, T. 13 N., R. 2 W. D, F, I, K.
55. Sallust Creek, sec. 29, T. 14 N., R. 2 W., E, I, L.
56. Crittenden Creek, sec. 3, T. 14 N., R. 2 W. D, F, I, N.

List of Species

Lampetra lamottei (LeSueur); American brook lamprey. 17, 22, 23, 26.

Lepisosteus osseus (Linnaeus): longnose gar. 23, 34, 36.

Amia calva Linnaeus; bowfin. 17.

Dorosoma cepedianum (LeSueur); gizzard shad. 2, 34, 35, 36.

Ictiobus cyprinellus (Valenciennes); bigmouth buffalofish. 45.

Carpiodes cyprinus LeSueur; quillback carpsucker. 2, 13, 15, 25, 34, 35, 36.

Moxostoma anisurum (Rafinesque); silver redhorse. 34.

Mosotoma erythrurum (Rafinesque) golden redhorse. 1, 4, 5, 12, 13, 15, 16, 18, 19, 22, 26, 32, 33, 34, 35, 36, 38, 39, 40, 44, 47, 49.

Moxostoma breviceps (Cope); Ohio shorthead redhorse. 34, 35.

Hypentelium nigricans (LeSueur); hog sucker. 1, 2, 3, 5, 6, 8, 10, 11, 12, 17, 18, 20, 21, 22, 23, 25, 26, 27, 29, 32, 33, 34, 35, 36, 38, 39, 40, 49, 50, 52, 53, 56.

Catostomus commersoni commersoni (Lacepede); common white sucker. 2, 4, 6, 8, 9, 11, 12, 13, 15, 19, 21, 22, 25, 26, 32, 34, 35, 36, 38, 39, 40, 41, 49, 50, 51, 52, 53, 56.

Minytrema melanops (Rafinesque); spotted sucker. 15, 22, 32, 34, 35, 36.

Erimyzon oblongus claviformis (Girard); western creek chubsucker. 52, 54.

Cyprinus carpio Linnaeus; carp. 2, 15, 47.

Notemigonus crysoleucas (Mitchill); western golden shiner. 52.

Hybopsis amblops (Rafinesque); bigeye chub. 9, 12, 18, 19, 23, 25.

Hybopsis biguttata (Kirtland); hornyhead chub. 8, 12.

Hybopsis micropogon (Cope); river chub. 1, 2, 3.

Rhinichthys artatulus melaegris Agassiz; western blacknose dace. 5, 6, 21, 25, 26, 29, 30, 40, 50, 53, 54, 55, 56.

Semotilus atromaculatus atromaculatus (Mitchill); northern creek chub. All stations *except* 2, 4, 6, 9, 19, 23, 26, 32, 37, 39, 42, 44, 45, 46, 48, 50.

Phenacobius mirabilis (Girard); suckermouth minnow. 2, 3, 13, 15, 25, 34, 35, 36, 39, 49, 52, 54.

Chrosomus erythrogaster Rafinesque; southern redbelly dace. 5, 6, 22, 30, 40, 42.

Notropis atherinoides atherinoides Rafinesque; river emerald shiner. 34.

Notropis rubellus (Agassiz); rosyface shiner. 2, 3, 15, 18, 19, 33.

Notropis umbratilis (Girard); redfin shiner. 4, 11, 13, 17, 18, 19, 20, 21, 22, 28, 32, 33, 34, 35, 36, 42, 46, 49 50, 51, 52, 55.

Notropis cornutus chrysocephalus (Rafinesque); central common shiner. 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13, 14, 15, 18, 19, 22, 23, 24, 26, 28, 29, 31, 33, 34, 35, 36, 38, 40, 41, 42, 43, 49, 50, 52.

Notropis boops Gilbert; bigeye shiner. 4, 12, 24, 26, 36, 37.

Notropis whipplei (Girard); steelcolor shiner. 50.

Notropis spilopterus (Cope); spotfin shiner. 1, 2, 3, 5, 8, 10, 14, 15, 17, 18, 19, 20, 24, 26, 32, 33, 34, 35, 36, 38, 45, 46, 47, 48, 49, 50, 52, 53, 54.

Notropis deliciosus deliciosus (Girard); southern sand shiner. 3, 8, 11, 15, 17, 18, 19, 25, 33, 34, 35, 46, 48, 49, 50, 54.

Ericymba buccata Cope; silverjaw minnow. 1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18, 20, 21, 22, 23, 24, 25, 26, 28, 29, 33, 34, 35, 36, 38, 39, 40, 41, 43, 46, 47, 49, 50, 52, 54, 55, 56.

Pimephales notatus (Rafinesque) bluntnose minnow. All stations except 7, 16, 30, 32, 37, 44, 45, 47, 53.

Campostoma anomalum (Rafinesque); stoneroller. 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 17, 18, 20, 21, 22, 23, 24, 25, 26, 28, 29, 30, 31, 34, 35, 36, 38, 39, 40, 41, 43, 46, 49, 51, 52, 54, 56.

Ictalurus punctatus (Rafinesque); channel catfish. 15, 35, 36.

Ictalurus natalis (LeSueur); yellow bullhead. 12, 31, 35, 41, 43, 54.

Ictalurus melas (Refinesque); black bullhead. 8, 12.

Noturus flavus (Rafinesque); stonecat. 15.

Noturus miurus (Jordan); brindled madtom. 2, 15, 17, 26, 35, 39.

Fundulus notatus (Refinesque); blackstripe topminnow. 4, 12, 19, 34, 35, 36, 41, 47, 49, 52, 53, 54.

Labidesthes sicculus sicculus (Cope); northern brook silverside. 14, 34, 35, 36, 51.

Pomoxis annularis (Rafinesque); white crappie. 2, 14, 34, 35, 36, 37, 43, 44.

Pomoxis nigromaculatus (LeSueur); black crappie. 44.

Ambloplites rupestris rupestris (Rafinesque); northern rock bass. 2, 4, 12, 15, 19, 22, 23, 32, 34, 35, 36, 38, 42.

Micropterus dolomieui dolomieui Lacépède; northern smallmouth bass. 1, 2, 5, 12, 13, 18, 19, 23, 25, 26, 27, 30, 32, 34, 35, 36, 38, 42.

Micropterus punctulatus punctulatus (Rafinesque) northern spotted bass. 1, 15, 34, 35, 37, 46.

Micropterus salmoides salmoides (Lacepede); northern largemouth bass. 2, 8, 12, 22, 34.

Lepomis cyanellus Rafinesque; green sunfish. 6, 7, 13, 19, 21, 24, 28, 31, 34, 35, 36, 40, 41, 42, 52, 53, 54.

Lepomis macrochirus macrochirus (Rafinesque); northern bluegill. 1, 8, 13, 26, 34, 35, 36, 41, 42, 43, 45, 48, 49, 50.

Lepomis humilis (Girard); orangespot sunfish. 35, 36.

Lepomis megalotis megalotis (Rafinesque); central longear sunfish. 1, 2, 4, 8, 12, 16, 18, 19, 20, 21, 23, 24, 26, 34, 35, 36, 38, 39, 41, 43, 44, 45, 47, 49, 52, 53, 54.

Percina maculata (Girard); blackside darter. 15, 18, 19, 34, 35, 36.

Percina caprodes caprodes (Rafinesque); Ohio logperch. 9, 12, 13, 34, 35, 36, 38, 39.

Ammocrypta pellucida (Baird); northern sand darter. 14, 15, 18.

Etheostoma nigrum nigrum (Rafinesque); central Johnny darter. 3, 6, 7, 10, 11, 12, 13, 18, 20, 21, 22, 25, 27, 28, 30, 34, 35, 36, 38, 39, 40, 41, 43, 47, 49, 50, 52, 54, 56.

Etheostoma blenniodes (Rafinesque); greenside darter. 3, 5, 12, 15, 17, 18, 23, 25, 33, 34, 35, 36, 38, 46, 54.

Etheostoma caeruleum (Storer); rainbow darter. 1, 5, 6, 8, 11, 12, 13, 15, 18, 19, 21, 22, 23, 25, 27, 30, 33, 34, 35, 36, 38, 39, 42, 43, 51.

Etheostoma spectabile spectabile (Agassiz); northern orange-throat darter. 6, 13, 15, 20, 28, 29, 40, 43, 51, 53, 54, 55, 56.

Etheostoma flabellare (Rafinesque); fantail darter. 7, 11, 12, 19, 21, 22, 23, 25, 26, 33, 34, 35, 36, 39, 43.

Aplodinotus grunniens (Rafinesque); freshwater drum. 34, 44.

Cottus bairdi bairdi (Girard); northern mottled sculpin. 5, 6, 9, 21, 22, 27, 28, 40, 43.

Discussion

A total of 60 species of fish belonging to 13 families were identified. Forty of the forty-eight species recorded for the study area by Gerking (1945) were found, and twenty additional species were captured.

Two specimens of Catostomids have been identified tentatively as *Moxostoma breviceps*, a species which has not been reported from Indiana since Jordan collected it in 1888 (Jordan, 1890). These two individuals seem to be identical in certain key characteristics to specimens collected in Big Walnut Creek in 1941 by Gerking, who identified them as *Moxostoma aureolum*. The ranges of *Moxostoma breviceps* and *M. aureolum* are distinct and separate except in Indiana where intergradation might possibly occur (Trautman, 1957, page 256). More specimens and work are needed before the exact taxonomic status of these individuals can be determined.

A total of 18 species had a widespread distribution throughout the study area. Ten of these usually had high population densities (*Moxostoma erythrurum, Hypentelium nigricans, Semotilus atromaculatus atromaculatus, Notropis cornutus chrysocephalus, Notropis spilopterus, Ericymba bucatta, Pimephales notatus, Campostoma anomalum, Lepomis megalotis megalotis* and *Etheostoma nigrum nigrum).* The other eight species were taken regularly, but the populations were much smaller *(Catostomus commersonii, Phenacobius mirabilis, Notropis deliciosus deliciosus, Notropis umbratilis, Fundulus notatus, Lepomis cyanellus, Lepomis macrochirus macrochirus,* and *Etheostoma spectabile spectabile).*

Three other species were widely distributed and fairly abundant, except for their absence above Cataract Falls (*Ambloplites rupestris rupestris, Etheostoma caeruleum* and *Etheostoma flabellare).* Thirteen additional species which were not captured above the Falls were taken at six or more stations elsewhere. It may not now be possible to determine if these species were blocked by the Falls because of extensive man-made changes in the habitat. Nevertheless, more intensive collecting might more firmly establish their presence or absence.

Most of the 20 species taken in this study that were not found by Gerking (1945) were probably present 20 years ago, but were not captured because of the localized nature of the populations or the scarcity of individuals. Two species, however, are presently so abundant in some of the streams that they almost surely have entered the area fairly recently. Good numbers of gizzard shad, *Dorosoma cepedianum,* now inhabit the lower part of Deer Creek and that part of Raccoon Creek above Mansfield Reservoir. The impoundment of Raccoon Creek has no doubt contributed greatly toward their success here. The river chub, *Hybopsis micropogon,* has become firmly established in Raccoon Creek and is now abundantly present both above and below Mansfield Reservoir.

Summary

The distribution of fishes in an area of approximately 1000 square miles including all of Putnam County and parts of Clay, Parke, Montgomery, Boone, Hendricks and Morgan Counties was studied during

1962, 1963 and 1964. Collections were made at 56 sites on the mainstreams and tributaries of Raccoon Creek north of the town of Mansfield, Deer Creek, and Big Walnut and Mill Creeks above their junction with each other. A total of 60 species of fish belonging to 13 families were identified. Two specimens of Catostomids have been identified tentatively as *Moxostoma breviceps. Ambloplites rupestris rupestris, Etheostoma caeruleum* and *Etheostoma flabellare* were not found above Cataract Falls, but were widely distributed and fairly abundant elsewhere. Thirteen other species which were not collected above the Falls were taken at six or more sites elsewhere. Within the past 20 years, the gizzard shade (*Dorosoma cepedianum*) and the river chub (*Hybopsis micropogon*) have entered the area and have become firmly established in some stream systems.

Literature Cited

1. Gerking, S. D. 1945. The distribution of the fishes of Indiana. Investigations of Indiana Lakes and Streams 3(1): 1-137.
2. Gerking, S. D. 1955. Key to the fishes of Indiana. Investigations of Indiana Lakes and Streams 4:49-86.
3. Jordan, D. S. 1890. Report of explorations made during the summer and autumn of 1888 in the Allegheny region of Virginia, North Carolina and Tennessee, and in Western Indiana, with an account of the fishes found in each of the river basins of those regions. Bull. U. S. Fish. Comm. 1888, 8:97-173.
4. Trautman, M. B. 1957. The fishes of Ohio. The Ohio State Univ. Press, Columbus, Ohio. 638 p.

Another Cat with an "Upside-Down" Stomach

J. Hill Hamon, Indiana State College

Anomalies in anatomic structures can be found in virtually every group in the Animal Kingdom. The most commonly encountered deviations involve small characters such as the variation of site of origin of smaller arteries on the aorta, or a "different" arrangement of the postcava and its many tributaries. One of the more unusual, and sometimes spectacular malformations that students may encounter in their laboratory cat cadavers is a diaphragmatic hernia.

Diaphragmatic hernias are not common in cats. When, during embryonic development, the edge of the transverse septum fails to fuse properly with the edge of the pleuro-peritoneal membrane to form the diaphragm, a hole results through which the viscera may protrude into the thoracic cavity.

A small female cat turned up recently in my comparative vertebrate anatomy laboratory that was afflicted with such a hernia. Figure 1 is a photograph of this unusual specimen. The lungs were very small, and were greatly compressed by the intestines. The stomach and spleen were greatly enlarged, and the kidneys, liver, and ovaries are in unusual positions. This cat is similar, in a number of characteristics, to a case reported by Reifenburgh, Lawson, and Ogden. (Proc. Indiana Acad. Sci., 7:285.286.)

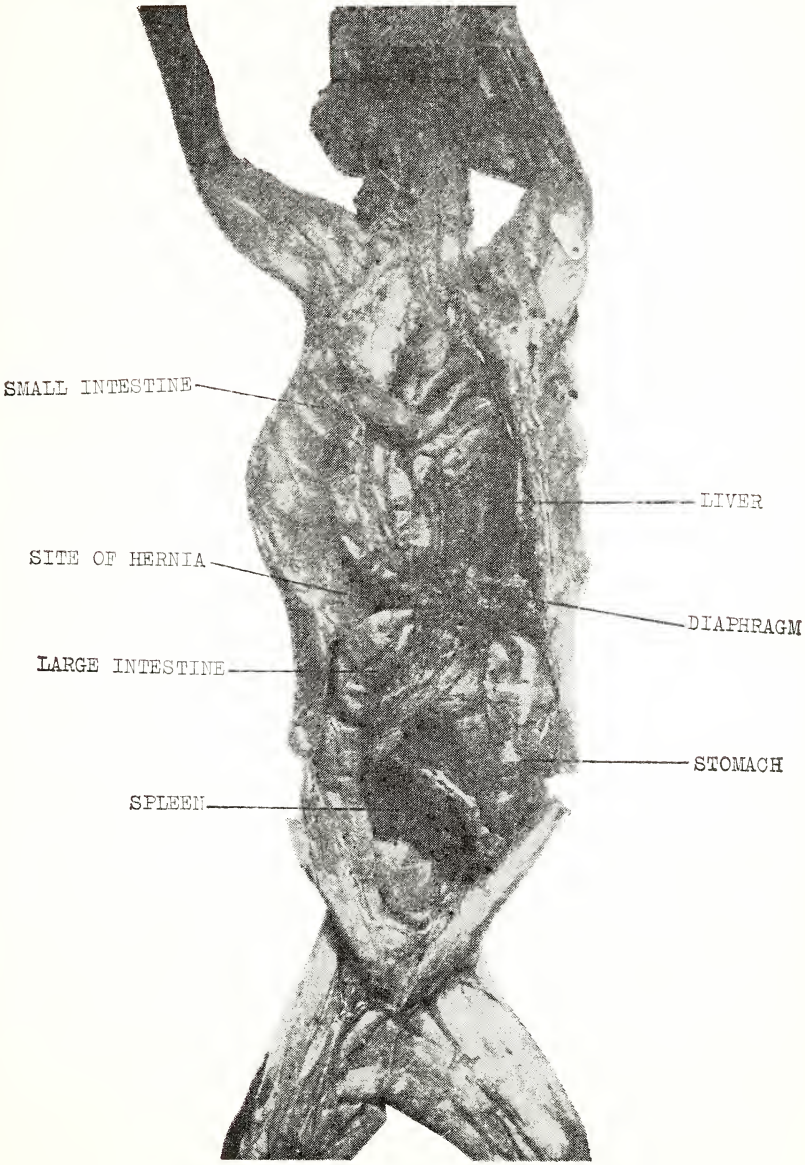

SMALL INTESTINE
LIVER
SITE OF HERNIA
DIAPHRAGM
LARGE INTESTINE
STOMACH
SPLEEN

Fig. 1

Further Observations on Effect of Nonoptimally High Incubation Temperature on Frequency of Pecking And Color Preference in the Chick[1]

W. C. GUNTHER, Valparaiso University

Introduction

The results of our previous investigations have indicated that the critical period for embryonic nervous system development in chicks is during the early part of the incubation period; this suggests that during this time the embryo should be as free from stress as possible. Gunther (2, 3) and Gunther and Jones (4-8) have described various types of structural, behavioral, and physiological abnormalities in the subsequently hatched animals when nonoptimally high temperature was the stressor during the first several days of incubation of chick eggs, that is, during the early period of the development of the nervous system. Romanoff (9) summarizes some of the effects of higher temperature, including those on the brain and spinal cord.

Gunther and Jones (6, 7), appear to be among the first investigators to suggest, and to provide experimental evidence (at least in the terminal stages), that heat stress at any time during the embryonic period is damaging to the nervous system and that such damage will produce defects in behavior, possibly as much during subsequent phases as during the initial phases of incubation.

It will be interesting to follow up this research with application of heat to normal-temperature chicks immediately after hatching, since the thermo-regulatory mechanism is said to be inoperative until about the seventh post-hatching day (10, 11; Gunther, unpublished data). Also unexplored is the application of heat stress during the middle of the incubation period, from incubation days 5 through 15. Work on these aspects is scheduled in the laboratory.

In a previous work on pecking frequency and on color preferences (5) it was found that the heat-stressed birds (incubated initially for 3 days at 41° C.) pecked at the targets less frequently than did the control animals, and that the stressed chicks preferred the blue-green region of the spectrum whereas the control birds preferred the yellow-orange region. The research reported herein is designed to compare the pecking frequency and the orange-black preference of chicks hatched from eggs incubated initially and terminally for 36 hours at 41° C. with the pecking frequency and color preferences of chicks hatched from eggs incubated at the optimal temperature of 37.5° C. for the entire period of incubation.

---

[1]Supported by research grant HD-00202 National Institute of Child Health and Human Development, United States Public Health Service, and by research grant from Grass Foundation.

Materials and Methods

Two-hundred forty White Rock eggs (called experimentals) were incubated initially at 41° C. for 36 hours, transferred to normal temperature (37.5° C.) incubators for 18 days, then returned to the 41° C. incubator until hatched. An additional 240 eggs (called controls) were incubated for the entire incubation period of 37.5° C. Incubators, conditions of incubation and hatching, etc., have been described in previous publications.

One-hundred ninety controls and 115 experimentals hatched. The experimentals hatched somewhat precociously, all in about 20 hours after being returned to the 41° C. incubator on day 19½. The controls hatched on day 21 of the incubation period, from 10 to 20 hours after the experimentals.

Forty-three controls and 43 experimentals were run in the pecking apparatus. These chicks were all experimentally naive and were handled only when transferred to and from the pecking apparatus, and when switched from side to side in the pecking apparatus. Since effects of handling are as yet incompletely understood, it was decided to handle the chicks as little as possible. Work in the laboratory subsequent to this research indicates that handled chicks perform significantly faster in learning situations.

The pecking apparatus has been described (5). The targets on the cylinders consisted of a ¼" black or orange dot, painted on the inside of a clear plastic disc on the end of the cylinder. The black paint was a Smith-Alsop product, Saco Sheen Black; the orange paint was a special mix, judged by 3 independent observers to approximate most closely the color of the dull side of Ostwald chip #3 from the Ostwald color harmony manual (1). The cylinders were attached to the arms of microswitches. Each time the cylinder was moved—that is, when the chick pecked at it—the circuit was closed and an electric counter connected to the microswitch was moved ahead one integer. Since each cylinder, target, microswitch, and counter functioned as a unit, it was possible to record automatically and accurately the number of pecks delivered to each target. Pecking frequency was determined by using the black dots only on all 16 cylinders. As is customary, the experimentals and controls were tested simultaneously, separated from each other in the pecking apparatus by a wooden partition. The orange-black preference task was run by placing orange and black dots on alternating microswitches. Thus, during any testing period there would be 8 alternating orange and black targets on each side of the wooden partition. The birds were interchanged from one side to the other at 1½ hour intervals, or once during each 3-hour testing session. Each test was run for two weeks, one 3-hour session each day. The chicks were deprived of food, but not water, approximately 12 hours prior to each testing session. When the chicks were one week old they were first run for 2 weeks on the black dot targets in the pecking frequency test, and after three weeks of rest they were tested for another two-week period on the orange-black combination.

Results and Discussion

Table 1 summarizes the results of the pecking frequency test. The chi-square value indicates a very highly significant difference in the number of pecks delivered, the controls pecking more frequently than the experimentals. There appeared to be no diminution of or other change in pecking frequency with increased age of the chicks. This was mentioned as a possibility in a previous report (5).

The result of the orange-black preference test is shown in Table 2. It is seen that both groups showed a significant preference for orange over black. The strength of this preference was about the same in the 2 groups.

TABLE 1

Pecking frequency of control and experimental groups
Targets: Black dots

Group	Total responses	n	Chi-square (1 df)
Control	6,836	43	731.62*
Experimental	4,018	43	731.62*

* Highly significant difference; $P = < .001$

TABLE 2

Orange-black preference test in the pecking apparatus
Targets: Orange and black dots, alternated

Group	Total Responses	Stimulus Combination	Preferred Stimulus	n	Chi-square (1 df)
Control	5,655 3,589	Orange-Black	Orange	43	461.74*
Experimental	3,635 2,016	Orange-Black	Orange	43	463.92*

*Highly significant difference; $P = < .001$

The difference in pecking frequency is very similar to that seen in a former experiment (5). The controls peck much more frequently than do the experimentals. One might conclude that the experimentals are less active and that the heat stress in general depresses motor activity. Observations of the chicks, however, do not support this theory. The experimental chicks eat as much as the controls, and are every bit as active in other situations; they may not be aware of their surroundings as the controls. The disturbance causing this depressing action on pecking activity is probably one involving several brain levels, among which are learning, innate response to pecking and perhaps to color, and black-white recognition or discrimination. These results do not provide any clue as to the nature of the damage (to the brain or other locus).

Proportionately the orange-black preference experimentals delivered far more pecks to the targets than did the color preference experimentals from a previous experiment (5) in which the chicks were hatched from eggs placed in the nonoptimally high temperature initially for 3 days. One might conclude that the depressing effect of such stress is lessened when spread over 2 widely-separated incubation periods, that is, 1½ days initially and 1½ days terminally. However, since the experimental chicks in this experiment received on the average about 16 hours less exposure to the heat stress, it would be equally valid to state that this is the reason for the difference. A third possibility is that the number of different colors (16 spectral hues) in the previous experiment mentioned above tended to confuse the experimental chicks, depressing their pecking activity considerably. The relatively simple choice of orange or black left little room for hesitancy of choice, which might tend to lower the pecking frequency of the experimentals, other than the usual depressed pecking frequency of heat-stressed birds. This is suggested by the comparison of the total number of pecks delivered to the targets by both groups in both of these situations. On the black dots the experimentals delivered 37% of the total pecks registered, and on the orange-black targets the experimentals also delivered 37% of the total pecks registered. In other words, there was no difference in the percentage of pecks registered in the two situations. This seems all the more convincing when one takes into consideration the fact that the two experiments were separated by a time interval of three weeks.

The preference of orange over black for both groups is interesting in the light of previous research (5). It was mentioned as a possibility then that perhaps some kind of imprinting had occurred, promoting the preference of the controls for orange and the experimentals for blue. This nebulous preferential imprinting, though interesting as a theory, hardly seemed to bear up under close scrutiny. It was true, however, that the chicks in that experiment had been exposed to all the different color stimuli several days before testing had been begun. Nevertheless, for various reasons it appeared doubtful that imprinting played any role in that experiment. In the research reported here the birds had first been exposed to the black discs for frequency of pecking. After a three-week rest they had been run in the pecking apparatus with alternate orange and black targets. If any imprinting had occurred it should have been on the black. Actually, both controls and experimentals preferred orange to about the same extent (61% and 64% respectively). This would tend to discredit a differential imprinting theory. The lack of any difference in the orange preference of either group indicates that either the duration of the heat stress was too short to alter the normal orange preference, or the stress imposed during the final days of incubation produced little or no effect on the as yet unsolved neural bases of color preference behavior.

Summary

Chick eggs were exposed to the nonoptimally high temperature of 41° C. for the first 1½ days of incubation, transferred to normal temperature incubators until day 19½, and then transferred to the 41° C.

incubator until hatching. The hatched chicks were compared with control chicks incubated at the optimal temperature of 37.5° C. for the entire incubation period. Both groups were tested simultaneously in a pecking apparatus over a period of 6 weeks.

Pecking frequency in the controls was significantly higher than in the experimental chicks.

Orange over black was preferred by both controls and experimentals to about the same degree. This preference was highly significant.

Discussion centered on comparison with previous work in which it was found that controls preferred the orange-yellow and experimentals the blue-green region of the spectrum (the latter chicks being incubated under somewhat different conditions, however).

Literature Cited

1. Color Harmony Manual, 3d Edition. 1948. Container Corporation of America, Chicago.
2. Gunther, W. C. 1964. Oxygen uptake in heat-stressed chick embryos. Proc. Ind. Acad. Sci. **73**:261-266.
3. ————————. 1958. Effect of abnormal incubating temperature on chick behavior. Proc. Ind. Acad. Sci. **68**:363-366.
4. Gunther, W. C. and R. K. Jones. 1963. Some effects of nonoptimally high incubation temperatures on chicken blood chemistry. Proc. Ind. Acad. Sci. **72**:353-361.
5. ————————. 1963. Effect of nonoptimally high temperature on frequency of pecking and on color preferences in the chick. Proc. Ind. Acad. Sci. **72**:290-299.
6. ————————. 1962. Effect of environmental stress on chick weight. Proc. Ind. Acad. Sci. **71**:385-398.
7. ————————. 1962. Effect of nonoptimally high incubation temperatures on T-maze learning in the chick. Proc. Ind. Acad. Sci. **71**:327-333.
8. Gunther, W. C., Robert K. Jones, and Paul Manske. 1961. The effect of high and low incubating temperatures on chick behavior. Proc. Ind. Acad. Sci. **70**:285-292.
9. Romanoff, Alexis L. 1960. The Avian Embryo. The Macmillan Company, New York.
10. Romijn, C. and W. Lokhorst. 1955. Chemical heat regulation in the chicken embryo. Poultry Sci. **34**:649-654.
11. ————————. 1956. The caloric equilibrium of the chicken embryo. Poultry Sci. **35**:829-834.

Vitamin Deficiency and Survival of Hepatoma BW7756 Mice

WILLIAM C. CLARK, Indiana University, Indianapolis

Introduction[1]

Neoplastic tissue in general is a rapidly growing tissue and has substantial requirements for metabolic energy and materials to maintain its integrity. Tumors are reported to have lower levels of vitamins and enzymes than normal tissues and it has been suggested that these deficiencies may offer an approach to tumor chemotherapy (1). Pyrodoxine and riboflavin have been shown to be present in low concentrations in certain neoplasms and their metabolic antagonists, desoxypyridoxine and U-2113, a riboflavin antagonists, have been demonstrated to inhibit growth of the 755 mouse tumor (1, 2).

The present investigation was undertaken to extend the studies of inhibition of tumor growth by pyridoxine and riboflavin deficiencies, mentioned above, to BW7756 Hepatoma and to superimpose thiamine and folic acid deficiencies. Findings obtained in this study demonstrate inhibition of this hepatoma by prolonging the survival time of mice bearing this tumor from 110 to 208 per cent of that of control mice on a complete diet.

Materials and Methods

Animals: Male C57L/J mice 3 to 4 weeks old were obtained from the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine. Mice bearing the BW7756 tumor were also obtained from the same laboratory. Tumor fragments taken from these mice were used for implantation into the experimental animals.

Chemicals: Desoxypyridoxine hydrochloride was obtained from Nutritional Biochemical Corp., Cleveland, Ohio; isoriboflavin hydrochloride and oxythiamine chloride-hydrochloride were purchased from Calbiochem Corp., Los Angeles, California. Methotrexate (Lederle) was obtained through the Medical Center Pharmacy. The pyridoxine deficient diet was prepared by General Biochemical, Chagrin Falls, Ohio. The complete diet employed was Wayne Lab-Blox.

Tumor fragments were removed from pentobarbital anesthetized tumor bearing mice and immediately implanted subcutaneously in ether anesthetized mice. The statistical significance of the results were analyzed by the method of Fisher (3).

Results

I. Tumors grown 14 days in mice on complete diet: Tumor transplants were permitted to grow in the mice kept on the complete diet for 14 days at which time the tumor was palpable. The mice were randomly divided into four groups, a control group of six mice,

[1]The author gratefully acknowledges the responsible collaboration of Mr. John L. Dyer in this study.

and three test groups of thirteen mice each. The control mice were maintained on the complete diet and the test groups were fed the pyridixine deficient diet. These test groups are given either oxythiamine 100 mg per kg three times a day, isoriboflavin 100 mg per kg two times a day, or desoxypyridixine 37 mg per kg three times a day. The antagonists were dissolved or suspended in water and injected subcutaneously in the center area of the back. The doses were based on the weight of the mouse taken immediately before administration of the drug.

The antagonists were injected regularly until the mouse became so deficient that it would not walk away when gently pushed. When this state was reached, the mouse was placed in another cage and provided with the complete diet until it had sufficiently recovered to move away promptly when gently pushed. This procedure was repeated until the mouse died. The mouse and its tumor were weighed. Cannibalistic tendencies were noted in all groups of mice. The tumor was frequently cannibalized.

Mean survival time was measured from the start of treatment with antagonist and was 16.3± a standard error of 0.07 days for the control group which was kept on the complete diet and had received no antagonist. The mean survival time and standard error of the mean of the test groups were: oxythiamine treated, 33.2 ± 1.7; the isoriboflavin treated, 27.2 ± 2.8; and the desoxypyridoxine treated mice, 29.8 ± 1.8 days. The null hypothesis was rejected since the probability of such results being obtained by chance was less than one per cent in each of the three experiments (see Table 1).

II. Tumors grown 18 days in mice on complete diet: The tumor transplant was permitted to grow 18 days in mice on a complete diet and at this time the mice were randomly separated into four groups. The control group was given the complete diet until they died. The other three groups were also continued on the complete diet but were treated with vitamin antagonists. The vitamin antagonists were dissolved or suspended in one per cent carboxymethylcellulose and injected into tumor area in a volume of 0.1 to 0.2 ml once daily. These test groups were given a combination of: desoxypyridoxine, isoriboflavin and oxythiamine; desoxypyridoxine, oxythiamine and methotrexate; or desoxypyridoxine, isoriboflavin and methotrexate.

The mean survival time of the control group was 14.3 ± 1.2 days, and the mean survival times of the three test groups were 20.9 ± 0.8 days, 29.9 ± 2.3 days; and 20.9 ± 2.0 days, respectively. The first two test groups means were significantly different from that of the control experiment ($P < 0.1$ in both experiments). The mean of the last group was not significantly different from that of the control experiment ($P < 0.10$). The data are summarized in Table 1.

III. Tumors grown 21 days in mice on complete diet: After tumors had developed in mice on the complete diet, the animals were randomly divided into a control group and three test groups. The control group and two of the test groups were maintained on the complete diet. The first test group was placed on the pyridoxine deficient diet and

TABLE 1

Vitamin Deficiency and Survival of Hepatoma BW 7756 Mice

Mice	Diet	Antagonists	Dose Mg/kg	Survival Days[1] Mean	Range	Per Cent of Control	Statistical Significance Std. Error	Probability
			I. Fourteen Day Tumors[2]					
6	Complete	None	——	16.3	16-17	100	0.07	——
10	Pyridoxine def.	Oxythiamine	100	33.2	14-41	203	1.7	0.01
9	Pyridoxine def.	Isoriboflavin	100	27.2	15-34	167	2.8	0.01
13	Pyridoxine def.	Desoxypyridoxine	37	29.8	16-37	182	1.8	0.01
			II. Eighteen Day Tumor Mice[3]					
3	Complete	None	——	14.3	12-16	100	1.2	——
8	Complete	Desoxypyridoxine Isoriboflavin Oxythiamine	100 100 200	20.9	16-23	128	0.8	0.01
8	Complete	Desoxypyridoxine Oxythiamine Methotrexate	100 200 0.4	29.9	22-40	208	2.3	0.01
9	Complete	Desoxypyridoxine Isoriboflavin Methotrexate	37 100 0.4	20.9	12-31	146	2.0	0.01
			III. Twenty-one Day Tumor Mice[4]					
6	Complete	None	——	12.7	11-17	100	0.9	——
9	Pyridoxine def.	Desoxypyridoxine Oxythiamine	37 100	16.3	11-29	128	2.5	N.S.
9	Complete	Desoxypyridoxine Oxythiamine Methotrexate	37 100 0.4	17.3	12-25	136	1.7	0.01
7	Complete	Desoxypyridoxine Isoriboflavin Methotrexate	100 50 0.2	14	9-23	110	1.7	N.S.

[1]Days starting with administration of antagonists.

[2]Antagonists injected subcutaneously.

[3]Antagonists injected into tumor.

[4]Antagonists injected subcutaneously at tumor.

treated with desoxypyridoxine and oxythiamine; the second group was given desoxypyridoxine, oxythiamine and methotrexate; and the third group was treated with desoxypyridoxine, isoriboflavin and methotrexate once a day. The administration of antagonists was continued until the loss of activity as described above occurred. The administration of antagonists was then discontinued until recovery as described earlier. This regimen was repeated until death of the mice.

The mean survival time for the mice fed the complete diet and treated with desoxypyridoxine, oxythiamine and methotrexate (the second test group) had a significantly prolonged life, 17.3 $\pm$ 1.5 days when compared to the control mice, 12.7 $\pm$ 0.9 days ($P < 0.01$). Mean survival times of the other two experiments were not significantly different from that of the control experiments.

The weights of eleven tumors taken from the control experiment mice varied from 2.3 to 7.1 g and had a mean value of 4.6 g. Intact tumors were recovered from 71 of the vitamin deficient mice. Their weights varied from 1.9 to 7.6 g.

Seven of the vitamin deficient mice apparently died from overdose of vitamin antagonist or accident. Three of the deaths were in the first group and four were in the second group in section I of Table 1. These conclusions are based on the fact that these animals appeared to be in good condition the day before they were found dead and all these mice had small tumors. The largest tumor in these animals weighed 1.9 g. The other six tumors weighed less than 1.5 g. More significant prolongation of survival time was seen in the mice in which vitamin antagonism was started earlier (sections I and II vs. Section III of Table 1).

Summary and Conclusions

Combinations of vitamin deficiencies resulting from a pyridoxine deficient diet and the administration of the vitamin antagonists, desoxypridoxine, isoriboflavin and oxythiamine significantly prolonged the life of hepatoma BW7756 mice and inhibited the growth of this tumor. These findings are in agreement with those of Shapiro et al. (1, 4) who found similar vitamin deficiencies inhibited 755 mouse tumor growth. It is concluded that deficiencies of pyridoxine in combinations of riboflavin and/or thiamine significantly inhibit the growth of BW7756 mouse tumor and that further study in this area is indicated.

Literature Cited

1. Shils, M. E., I. M. Friedland, A. S. Fine, and D. M. Shapiro. 1956. Quantitative Biochemical Differences between Tumor and Host as a Basis for Cancer Chemotherapy. III. Thiamine and Coenzyme A. Cancer Res., **16**:581-584.
2. Shapiro, D. M., L. S. Dietrich, and M. E. Shils. 1956. Quantitative Biochemical Differences between Tumor and Host as a Basis for Cancer Chemotherapy. II. Riboflavin. Cancer Res. **16**:575-580.
3. Fisher, R. A. 1937. The Design of Experiments, 2nd Edition. Edinburgh. Oliver and Boyd.
4. Shapiro, D. M., M. E. Shils, and L. S. Dietrich. 1953. Quantitative Biochemical Differences between Tumor and Host as a Basis for Cancer Chemotherapy. I. Vitamin B_6. Cancer Res. **13**:703-708.

A Preliminary Study of the Turtle Population Of a Northern Indiana Lake

Susan E. Wade and Cameron E. Gifford, Earlham College

Introduction

A study of the turtle population of Dewart Lake, Kosciusko County, Indiana, was undertaken to determine the species of turtles present in a typical northern Indiana lake of glacial origin, and to estimate the population of the turtles in this lake. The weight, length, sex, and age of each individual turtle were determined and recorded. The area of operation for this study was a 55 acre bay on the southeast corner of Dewart Lake on which the David Worth Dennis Biological Station of Earlham College is located.

Methods

Two rectangular traps, one 5′ x 2½′ x 2½′ and one 4′ x 2′ x 2′, made of chicken wire with a wooden frame and an entrance funnel one foot shorter than the trap, were used to capture the turtles. These traps were baited with freshly killed fish, and were checked and emptied daily from predetermined areas in the bay. A Fyke net and various handnets were also used to capture individuals. The weight of each turtle was determined to the nearest gram; while the length, the curvature of the carapace, was determined to the nearest 10th of a centimeter. Each species of turtle was found to have different characteristics for determining the sex of the individual, such as size, coloring, or special adaptations for copulation. Thus no one system could be used to distinguish sex. Age was difficult to determine and the results of counting the annuli on the scutes of the carapace was so inconclusive that the data were rejected. This unreliability exists because the annuli became rubbed off, or lost during the natural course of the turtle's life. Each turtle that was caught was marked by notching the carapace so that recaptures could be identified and recorded. Thus, by knowing the number of new captures and the number of retakes, the turtle population of the area was estimated.

Results and Discussion

During this investigation approximately 575 turtles were captured, consisting of the seven following species: *Chelydra serpentina*, common snapping turtle; *Chrysemys picta marginata*, midland painted turtle; *Emydoidea blandingi*, Blanding's turtle; *Graptemys geographica*, common map turtle; *Pseudemys scripta elegans*, red-ear turtle; *Sternothaerus odoratus*, musk or stinkpot turtle; and the *Trionyx spinifer spinifer*, eastern spiny softshell turtle. Of these the most common species was the painted turtle with 341, or 59% of the total number caught. The musk turtle was also very abundant with a total of 197, or 34%, of the total number caught. The remaining 7% of the turtles were comprised of the other five species. So few of these were captured that

results were inconclusive as to the relation of weight, sex and length. Relations of length and weight were clearly shown in the painted and musk turtles as illustrated in the four tables in the appendix. Figure 1 illustrates that female painted turtles tend to be larger than the males. However, no such difference is shown in Figure 2, which compares the weights of the musk turtles since differences between the sexes of this species are due to adaptations for copulation, rather than to weight. Figures 3 and 4 show that the male and female painted turtles also vary in length while both sexes of the musk turtles are approximately the same length. This latter similarity may be due to many individuals living at maximum size or perhaps it is due to a particular year class.

Figure 1. Weight distribution of Male and Female *Chrysemys picta marginata.*

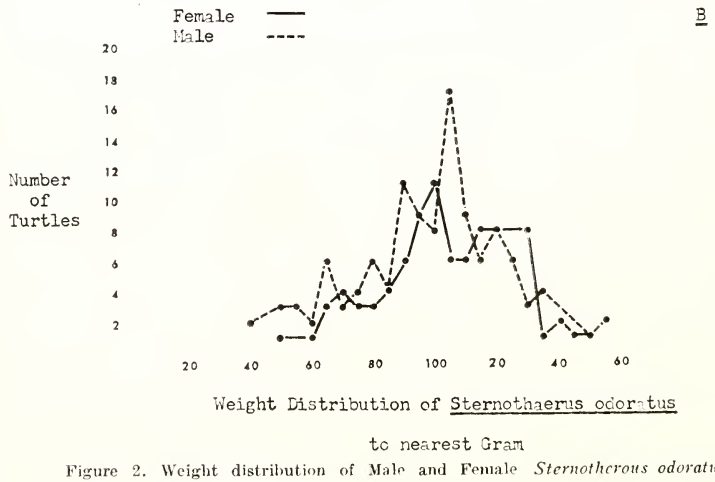


Figure 2. Weight distribution of Male and Female *Sternotherous odoratus.*

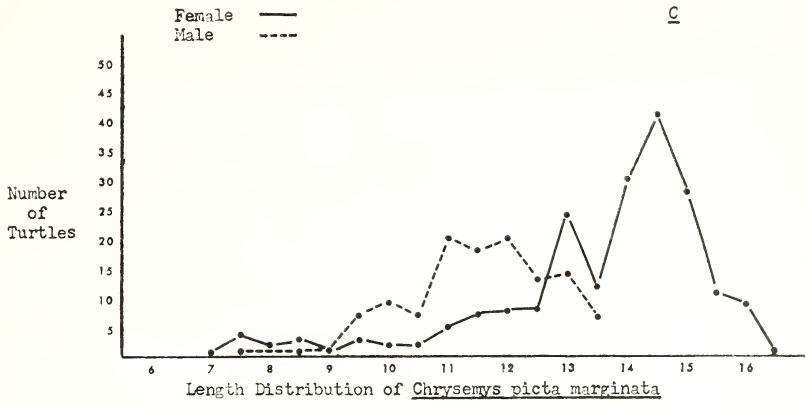


Figure 3. Length distribution of Male and Female *Chrysemys picta marginata.*

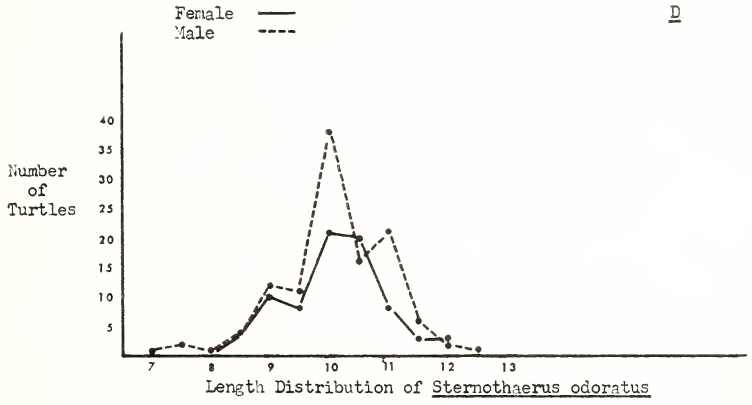


Figure 4. Length distribution of Male and Female *Sternotherous odoratus.*

Of the seven species of aquatic turtles collected the painted turtles and the musk turtles were most abundant simply because optimal conditions for living were present, these being shelter and food, both of which were given by the dense vegetation of the lake. Many young of the musk, painted and softshell turtles were captured but none of the snapping, red-ear, map and Blanding's turtles which would seem to indicate that either the young of these four species are not mobile or they live elsewhere until they are several years old. In the painted turtle more females were caught which would tend to indicate that they are more mobile or possibly more aggressive. More male musk turtles were collected suggesting that in this species, the male is more mobile. Turtles were collected either in the morning or in the afternoon. At both times the painted and musk turtles were

present, but the other five species were gathered only in the morning after the traps had been out all night. Thus, it appears that these turtles are mainly nocturnal in their habits.

Turtles caught in the traps were at least five years old since by then they had attained a size large enough so they would not fall through the holes of the chicken wire. Smaller turtles were caught in hand-nets while they sunned in the vegetation or on sandy banks. The turtles that sunned, such as the painted, Blanding's, red-ear, softshell, and map turtles, had less algae growing on their carapaces than the musk and snapping turtles which spend all of their time on or near the bottom of the lake in the vegetation (Carr, Handbook of Turtles). This would indicate that the lack of moisture caused by the drying action of the sun might have some control over algae growth.

The population of the bay was estimated using the Schnabel mark-and-recapture method in which the total daily catch, the daily recaptured turtles and the number of turtles not returned to the lake were recorded. From this the estimated population for the 55 acre bay was found to be 2736 turtles (all species were included). Calculating the 95% confidence interval, the estimated population fell between 2145 and 3772 turtles. Of the 575 turtles collected, 51 were recaptured. This is about 8.9% recapture rate which with the figure of the estimated population indicated that the turtle population of the bay was not small. All turtles were put back into the lake at one place in order to see if they would return to where they had been originally caught. Several did return which might tend to indicate a homing tendency, although insufficient data were obtained on this characteristic to tell with any degree of certainty.

Literature Cited

1. Carr, A., 1952. Handbook of Turtles, Comstock Publishing Associates, Ithaca, N. Y.
2. Conant, R., 1958. A Field Guide to Reptiles and Amphibians, Riverside Press, Cambridge.
3. Pope, C. 1939. Turtles of the United States and Canada, Alfred A. Knopf, New York.

Quantitative External Relationships in Two Species of Small Plethodons

ALBERT E. REYNOLDS and TIMOTHY A. STABLER, DePauw University

Interest in the relationships discussed herein was aroused initially when some routine field work resulted in our observing some cases of *Plethodon dorsalis* Cope which appeared to be unusually large. Measurements of these were compared with published records, and this led to an extension of the study to include additional collecting, a more comprehensive and thorough program of measuring, and expansion of the study to include *Plethodon cinereus* (Green) because of its general similarity to *P. dorsalis*. In characterizing and describing both groups, the standard systematic works make use of characteristics which are at basis quantitative (head length, tail length, etc.) and our interest lay in comparing such records with the actual data obtained from a substantial though not large sample of each salamander group. In his classical work of 1926, Dunn (3) considered these two taxonomic entities to be separate species, but Bishop (1) treated them both as subspecies of *P. cinereus*. Because of their very considerable resemblance to each other, and the consequent possibility of confusion concerning them, Thurow (5, 6) has presented a careful and extensive comparison of the two groups, based on very large samples; his account does not stress quantitative anatomical aspects, however. In his recent revision of the genus Plethodon, Highton (4) treated them as separate species.

Our data are based on 93 specimens of the zigzag salamander, *P. dorsalis* and 66 specimens of the red-backed salamander, *P. cinereus*, all collected in Putnam County, Indiana. Collecting was non-selective, but for this study no "dark phase" or unstriped animals were included; the salamanders discussed herein manifested either the zigzag yellow or red dorsal stripe of *dorsalis* or the similar but straight-edged stripe of *cinereus*. Measurements were made with micrometer calipers under uniform conditions in which the animals were under light chloretone anesthesia and posed in a natural but unstretched position. A number of calculations were made with the resulting information to produce for each animal index values that might be helpful in investigating certain anatomical relationships; methods of calculation are indicated in Table 1. Head lengths were measured from the tip of the snout to the gular fold of the salamander's neck region, trunk length extended from the gular fold to the anterior angle of the vent, and tail length from the latter point to the tip of the tail; only complete tail lengths were measured, however. The widths of both head and trunk were measured where these dimensions were maximal.

1. Body Size.

Conant (2) gave the "record" for *P. cinereus* as 125.0 mm (5 inches), while Bishop (1) gave the "extreme length" as 122.0 mm; Dunn (3) in his 1926 account cited total lengths of the order of 82 to 88 mm. In our series, among the 55 animals with tails of sufficient completeness

to measure a total length, the largest was a male of 106.0 mm. Five more specimens (3 females, 2 males) were 90.0 mm or more in total length. In the case of *P. dorsalis*, Bishop (1) credited Dunn (3) with recording the largest specimen at 87.0 mm; Conant (2) however gives the "record" as 3⅜ inches or 90.6 mm. In our series, 88 salamanders had complete tails and of these six exceeded Dunn's 87.0 mm. record. Two females and one male measured 87.5 mm, one female measured 88.5 mm, one male measured 90.0 mm, and one female exceeded Conant's record at 97.0 mm. Based on the six largest animals in the two species, the data just reviewed does not unequivocally support Bishop's (1) generalization that *dorsalis* is a smaller species than *cinereus*. Information in terms of means exhibited in Table 1 does not offer much additional clarification: Item 1 records a mean total length in *cinereus* some 4 mm greater than in *dorsalis*, while Item 7 records a mean snout-vent length in *dorsalis* some 4 mm greater than in *cinereus*.

TABLE 1

Quantitative Aspects of Salamander External Morphology

	P. cinereus		*P. dorsalis*	
	Mean	N	Mean	N
1. Total length, all cases	74.5	55	70.5	88
2. Total length, males	79.8	17	69.7	28
3. Total length, females	72.8	38	70.6	60
4. Trunk length, all cases	30.1	66	30.96	93
5. Trunk length, males	31.5	20	31.1	31
6. Trunk length, females	29.5	46	30.9	62
7. Snout-vent length, all cases	37.7	66	41.6	93
8. Tail length, all cases	36.5	55	33.8	88
9. Index = $\frac{\text{Snout-vent length}}{\text{Head width}}$	7.5	66	7.6	93
10. Index = $\frac{\text{Trunk length}}{\text{Trunk width}}$	6.4	66	6.1	93
11. Index = $\frac{\text{Trunk length}}{\text{Head length}}$	3.96	66	3.9	93

All values except index values are in millimeters

2. Tail Size.

That *P. dorsalis* has a shorter tail than *P. cinereus* has been recorded by both Dunn (3) and Thurow (5). The latter author makes a point of the fact that the shorter tail of *dorsalis* necessarily implies a more rapid taper which would make the tail constitute relatively a smaller proportion of the total mass of the organism. Reference to Table 1, Item 8, will show that in our series the *dorsalis* tail averaged about 3 mm less in length that the *cinereus* tail. The tail size in reference to the rest of the body presented interesting differences. In our *dorsalis*, of the 88 salamanders having complete tails, only 8 animals or 9% were exceptions to the rule that the snout-vent length exceeded the tail length. Such a degree of consistency was not observed, however, among the 55 specimens of *cinereus* which had complete tails; of these, 31 cases or 56% showed tail lengths less than snout-vent lengths,

a situation not to be expected in this long-tailed species where tail length may exceed snout-vent length by as much as 30%, according to Thurow (5).

3. Trunk Slenderness.

Our interest in the relative slenderness of the trunks of these two salamander groups stemmed from Bishop's (1) characterization of *P. dorsalis* as "smaller and more slender than its near relative, *P. c. cinereus*." Item 10 in Table 1 indicates the manner by which a slenderness index was calculated for each salamander. In *P. cinereus*, the six smallest and youngest specimens exhibited index values of 3.4 to 5.9, while the six largest and presumably oldest had values of 6.7 to 7.0, and the greatest value in any of the 66 *cinereus* was 7.9. With respect to *dorsalis*, the six smallest showed indices of 3.66 to 6.0, while the six largest had indices of 6.00 to 8.65, the latter being the greatest value seen in any of the 93 specimens. These data indicate that both species exhibit slenderization as an accompaniment of the growth process. This is verified by a case-by-case inspection of the data when all data are arranged in sequence in order of salamander size. Such an inspection, however, does not strongly suggest any material difference in the relative slenderness of one species as compared to the other. Index values in terms of means recorded in Table 1, Item 10, show very little difference, with *cinereus* being indicated as slightly more slender than *dorsalis*, if an index value difference of 0.3 is of any significance.

4. Head-Trunk Relationships

Dunn's (3) descriptions of both species gave the trunk length as four times the head length. For each of our specimens an index was calculated as given in Item 11 of Table 1. For all specimens of both species, the means of these indices, 3.96 for *cinereus* and 3.90 for *dorsalis*, are in essential agreement with Dunn's value of 4.0. In both species this index gives an additional measure of the allometric growth of the trunk as compared to the head. The smaller and younger specimens of both species exhibit indices as low as 2.4 to 3.0, while the older and larger specimens exhibit indices as high as 4.3 to 4.6.

Another of Dunn's (3) body-proportion characterizations gave the snout-vent length as 7 1/3 times the head width in *dorsalis*, seven times the head width in *cinereus*. Both of these values are too low as judged by our two series; Item 9 of Table 1 records this relationship as an index, the mean value of which is 7.5 for *cinereus*, 7.6 for *dorsalis*, so our data indicate very little difference between the two species in this relationship. This index also emphasizes the allometric nature of trunk growth: smaller *cinereus* have index values of 5.3 to 5.7, while the 11 largest have index values of 8.0 or more; in *dorsalis*, the smaller specimens evince indices of 4.6 to 4.7, while the largest specimens again have indices of 8.0 or more.

5. Sex Differences.

This facet of our study was provoked by Bishop's (1) comment that the *cinereus* male was usually shorter in body length, and in general smaller, than the female. In Table 1, Items 2, 3, 4, and 6 are pertinent

to this point, and our data do not support Bishop's statement; in terms of means, trunk length of males was about 2 mm greater than that of females, and in total length the discrepancy is even more marked, males some 7 mm longer than females. Our collecting was completely non-selective, yet the character of our sample may have biased these data. The smallest male *cinereus* was 28.5 mm in total length, 21.5 mm in trunk length, and our sample included six females which were smaller than this smallest male. Little comment need be made concerning *P. dorsalis*, since a glance at Table 1 will show that our data reveal little difference between the sexes in the attributes measured.

Literature Cited

1. Bishop, Sherman C. 1947. Handbook of Salamanders. Comstock Publishing Company, Ithaca, N. Y.
2. Conant, Roger. 1958. A Field Guide to Reptiles and Amphibians. Houghton Mifflin Company, Boston.
3. Dunn, Emmett Reid. 1926. The Salamanders of the Family Plethodontidae. Smith College Anniversary Publication, Northampton, Mass.
4. Highton, Richard. 1962. Revision of the North American Salamanders of the Genus Plethodon. Bull. Florida State Mus. **6**:23-367.
5. Thurow, Gordon R. 1956. Comparisons of Two Species of Salamanders, **Plethodon cinereus and Plethodon dorsalis**. Herpetologica **12**:177-182.
6. ————————. 1957. Relationships of the Redbacked and Zigzag Plethodons in the West. Herpetologica **13**:91-99.

The Effect of Pesticides on the Bluegill (Lepomis macrochirus) In a Northern Indiana Lake

James Michael Phelps, Jr., John R. Hastings, and James R. Gammon[1], Earlham College

Introduction

In an effort to control the entomological and other pest problems of the world, chemists have synthesized innumerable toxicant compounds in the twenty years since World War II. So rapid has been the production of these materials that, for many, their effects on the ecosystem in which they are used are little known.

It was the goal of this research supported in part by National Science Foundation Undergraduate Research Participation Grant GE-4070), to find readily identifiable symptoms which could be easily catalogued and used in an effort to differentiate, in a simple field identification, a particular chlorinated hydrocarbon toxicant which might be responsible for a fish kill.

Further, it was hoped that the effects of temperature on the reactions of poisoned fish could be observed. And, in a final series of experiments, the ability of a fish to recover from an exposure to one of the toxicants was tested.

The nine toxicants tested were: Aldrin (Technical Standard), Captan, Dieldrin (Technical Standard), DDT (Reference Standard), Edrin, Heptachlor, Lindane, Methoxychlor (Technical Standard), and 2-4-D.

Procedure

The tests were conducted on the bluegill sunfish *(Lepomis macrochirus)* because of its relative abundance at the David Worth Dennis Biological Station located on Dewart Lake where the research was conducted. The bluegill was also chosen because of its viability in captivity and its sensitivity to various toxicants (1). The specimens were obtained by fyke net, seines, rod and reel, and wire fish traps.

After a 72-hour period of acclimation, the specimens were transferred from 35-gallon stock tanks into 15-gallon commercial aquaria. Each aquaria contained 50 liters of water. Two fish were placed in each aquarium. The temperature of the water was maintained between 21°C. and 27°C.

The toxicants were added in acetone-toxicant solution (2) calculated to produce a concentration of toxicant to water of 1 part per million. The poisons were then thoroughly mixed with the water before the fish were introduced. Size selection of the fish was between 7 and 9 cm (Standard Length) and 90 and 155 grams.

The tanks were observed closely and symptoms of the fish were noted until death. After 100% mortality had been reached, each fish was dissected and examined for internal morphological aberrations which might have been caused by the pesticides.

[1]Present address: DePauw University, Greencastle, Indiana.

In the second series experiments, testing the effectivity of the toxicants at an increased temperature, the temperature of the water was maintained at 35°C. by standard aquarium heaters. All other procedure was the same as above.

The final series of experiments tested the ability of the bluegill to recover from the effects of poisoning once the initial symptoms of distress appeared. Two fish were added to each aquaria in the above mentioned manner. The concentration of toxicants in the tanks, however, was maintained at .1 p.p.m. rather than 1 p.p.m. At the first signs of distress, (generally a slight hypersensitivity) one of the fish was removed from the tank containing the toxicant, rinsed in the distilled water, and transferred to a tank containing 50 liters of uncontaminated water. Both of the fish were then observed until death.

Results

A definite pattern of potency was observed in all of the tests conducted. (see Graph 1). However, this potency seemed to increase as the three trials were conducted. This effect was thought to be caused by a residual toxicant remaining in the aquaria from one trial to another even though the aquaria were well scrubbed after each trial. Soaking the aquaria in a 1 molar solution of Sodium Thiosulfate after each trial seemed to correct this problem.

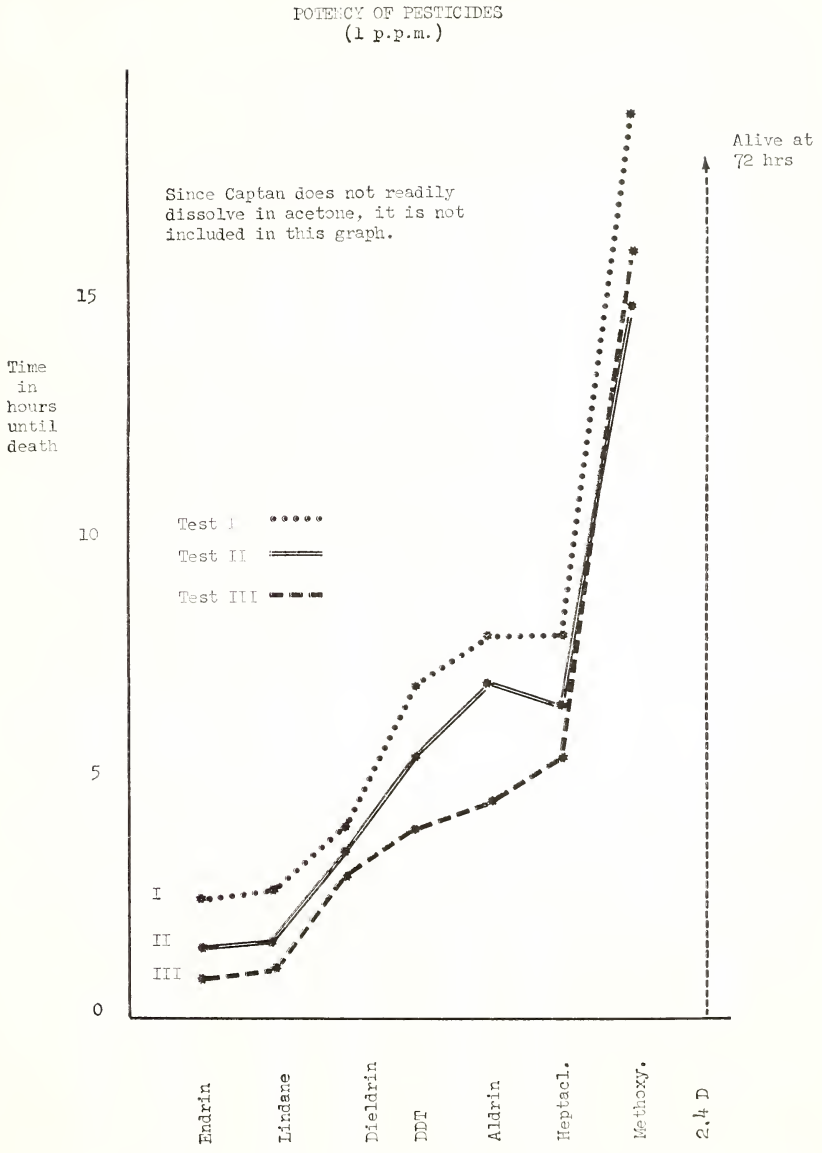
Also, the symptoms and aberrations caused by the toxicants are quite similar (See Table 1). It was observed that in a series of trials with one toxicant, the reactions varied as individual fish were affected. Ideally, to confirm the suspicion that a fish kill was caused by one of the above-mentioned chemical agents, the fish should be observed prior to death. It is in the symptoms that the effects of the chlorinated hydrocarbons are most clearly seen.

From an examination of the symptoms it would seem that these toxicants first affect the neural activity of the fish. Then, some of the agents attack specific organs of the body such as the liver and kidney where these organs can be seen to be hemorrhaged. Heptachlor, for example, causes severe hemorrhaging which is visible in the pelvic and pectoral fins. Captan, on the other hand, causes the large intestine to be partially everted through the anus.

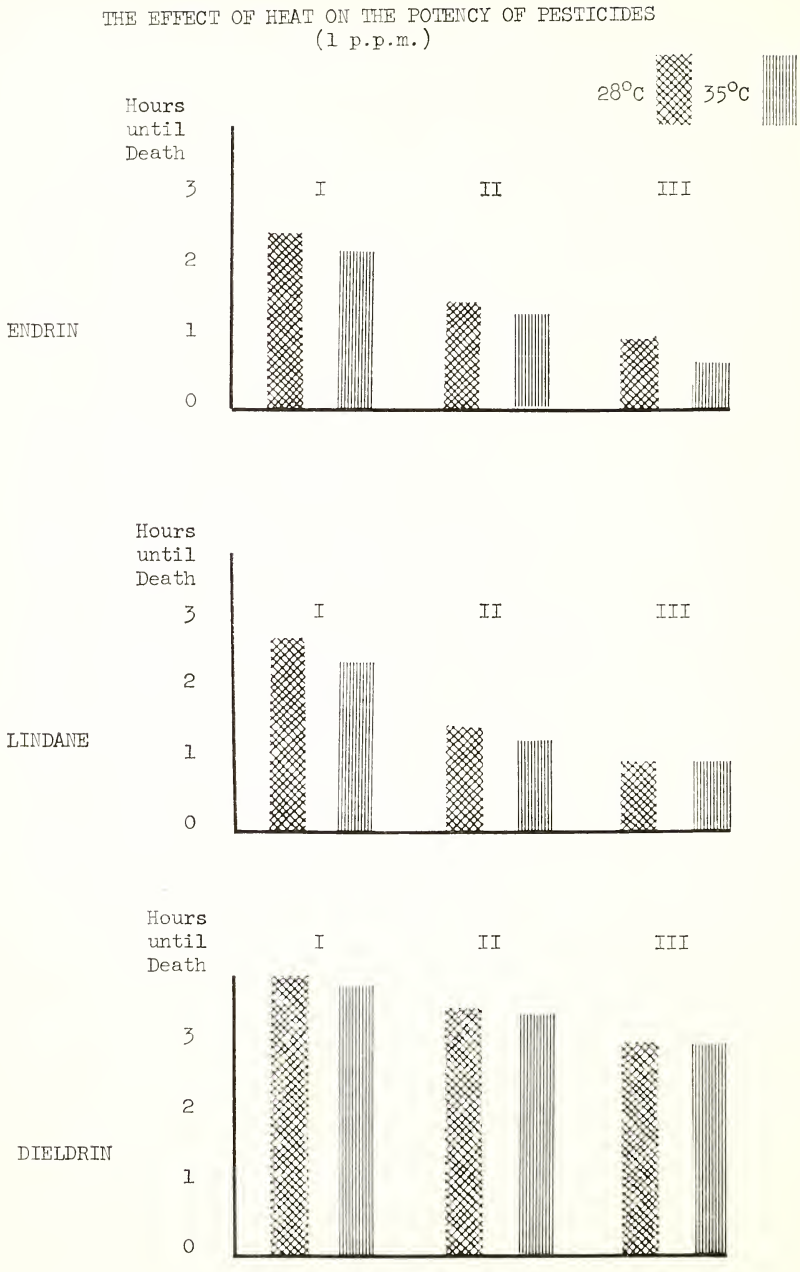
Therefore, it appears that a person investigating a fish kill would have a difficult time identifying the specificity of a certain toxicant which might be responsible for a fish-kill merely by observing symptoms or examination of the fish after death.

In an effort to determine the effect of temperature on the potency of pesticides, the three most toxicant compounds (Endrin, Lindane and Dieldrin) were selected. Temperature of the water was maintained at 35°C. In three trials each with Endrin, Lindane, and Dieldrin the data as shown in graph 2 indicates that the condition of the fish in warmer water deteriorated more rapidly than the condition of the fish in cooler water. It is thought that the warmer water increases the metabolism of the fish and thus, the absorption and circulation of the toxicant substances from the water is increased.

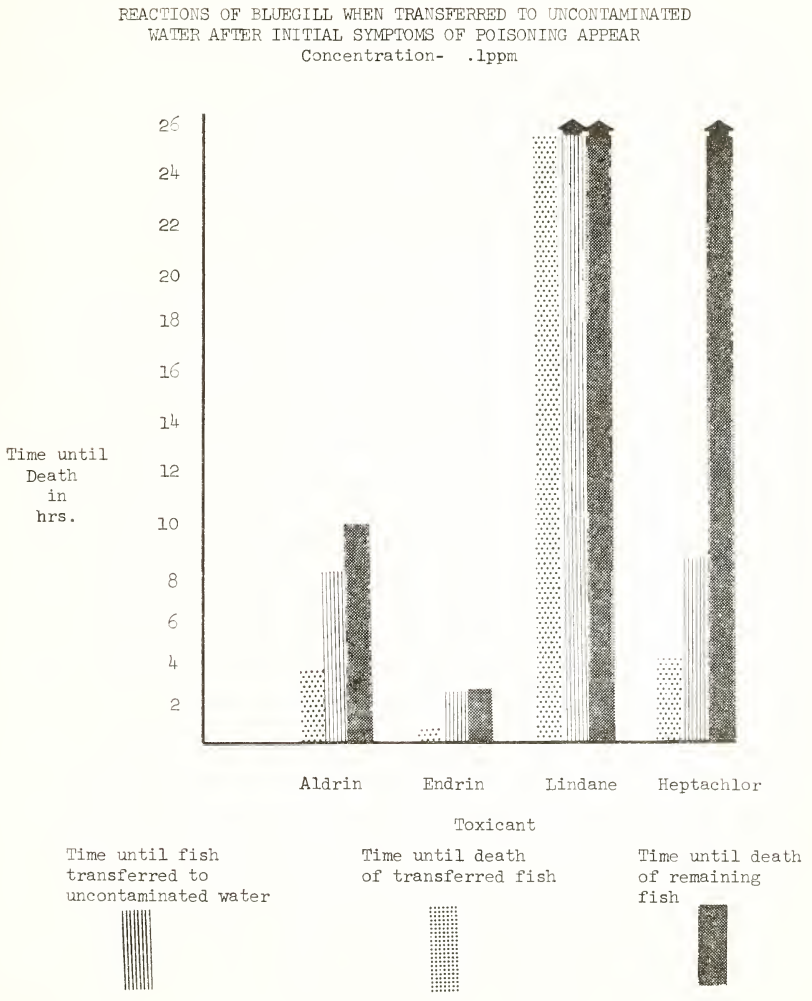
Of the four toxicants which were extensively tested in this experiment, the fish that was transferred to the uncontaminated water died


POTENCY OF PESTICIDES
(1 p.p.m.)
Since Captan does not readily dissolve in acetone, it is not included in this graph.
Alive at 72 hrs
Time in hours until death
15
10
5
0
Test I
Test II
Test III
I
II
III
Endrin
Lindane
Dieldrin
DDT
Aldrin
Heptacl.
Methoxy.
2,4 D

Graph 1


THE EFFECT OF HEAT ON THE POTENCY OF PESTICIDES
(1 p.p.m.)
28°C
35°C
Hours until Death
3
2
1
0
I
II
III
ENDRIN
LINDANE
DIELDRIN

Graph 2



Graph 3

sooner than the fish which remained in the poison. This indicates that, at least for these four compounds, death is inevitable once the initial symptoms have appeared (Graph 3.)

TABLE 1. Morphological abnormalities associated with short-term exposure to insecticides.

Toxicant	Before Death	After Death
Aldrin	Loss of equilibrium	Gills ruptured and bleeding Liver darker than normal and bleeding
Captan	Activity retarded during early stages of poisoning Respiration increase Spastic motions; loss of equilibrium Evidence of hemorrhaging in pelvic and pectoral areas	Kidney bloated and ruptured Intestine pushed through anus
Dieldrin	Loss of vertical equilibrium Irregular respiration Loss of color	No obvious defects
DDT	Hypersensitivity Loss of equilibrium Irregular respiration	No obvious defects
Endrin	Loss of color Fins rigid and erect Increased sensitivity Loss of equilibrium	Brain region watery Intestinal swelling Gills expanded
Heptachlor	Loss of equilibrium Hemorrhaging in pelvic area	Internal bleeding Liver bleeding
Lindane	Hypersensitivity Loss of equilibrium Coloration changes: fins darker at border, body lighter, top of head darker, pupil darker surrounded by light coloration	Brain damage Internal bleeding Intestine pushed through anus Liver damage
Methoxychlor	Loss of equilibrium	Gills slightly hemorrhaging
2, 4D	Signs of impaired respiration	No apparent defects

Summary

1. From a simple examination of symptoms or examination after death of a bluegill, it is difficult, if not almost impossible, to specify the toxicant responsible, in a simple field assay.

2. When bluegill are placed in water containing toxicant material, as the temperature of the water increases the time that it takes the fish to be affected by the toxicant decreases. This is thought to occur because increased temperature increases the metabolism of the fish causing more rapid absorption of the toxicant.

3. Once bluegill show the initial symptoms of poisoning, deterioration of the individual's health continues even though the subject is placed in uncontaminated water.

Literature Cited

1. Henderson, C., Q. W. Pickering and C. M. Tarzwell. 1959. Toxicity of Ten Chlorinated Hydrocarbons to Four Species of Fish. Transactions of the American Fisheries Societies.

2. Applegate, Vernon C., John H. Howell, A. E. Hall, Jr. and Manning Smith. 1957. Toxicity of 4,346 Chemicals to Larval Lampreys and Fishes, Special Scientific Report—Fisheries No. 207, Washington, D. C.

The Effects of Parental Age on Egg Production, Hatchability Of the Eggs, and Survival of the Offspring in *Drosophila melanogaster*

DENNIS M. O'BRIAN, CHARLES YABLONSKY, and CHARLES GILLOLY,
Seton Hall University

Introduction

The fact that the age of the parents has a definite effect on the survival of the offspring in *Drosophila melanogaster* is now well known (2, 9, 10). This investigation was understaken to establish additional criteria in order to determine the basis for parental age effects on the offspring in this species.

Methods

For fecundity studies all cultures were maintained under conditions of constant light at 25°C., while the groups selected for survival studies were raised at the same temperature under conditions of darkness and constant light. The stocks raised under conditions of darkness were exposed to light for observation at the same time period each day, total exposure to light not exceeding one hour per week. Adults of various ages from stock cultures of *Drosophila melanogaster* Meigen (Oregon-R strain) were placed in fresh culture bottles and eggs were collected for a period of 24 hours. The adults which emerged during the first 24 hours from these eggs were young from parents of various ages. Eggs were collected from these young adults during the first 48 hours following their emergence. The adults which emerged during the first 24 hours from this collection were used to set up the parental generation. The age of the parents was calculated on the basis of zero days at the time of the first adult emergence. Eggs were collected from this parental stock when the flies were 0 to 2, 2 to 3, and 30 to 31 days old. The offspring which emerged during the first 10 hours from these egg collections were used to set up the groups offspring from parents 0 to 2, 2 to 3, and 30 to 31 days following their emergence. In this manner the virginity of the non-mated offspring was insured.

The flies were transferred to fresh culture bottles at least every five days. For studies on fecundity the initial population density consisted of 5 females and 4 males per half-pint milk bottle for a total of at least 65 females and 52 males or 13 groups per parental age selection for the mated offspring, and 8 females per half-pint milk bottle for a total of at least 120 females or 15 groups for the non-mated offspring. For survival studies the initial population density consisted of a maximum of 8 females and 8 males per half-pint milk bottle for a total of at least 52 females and 55 males per selection in the mated populations, and a maximum of 15 females or 15 males per half-pint milk bottle for a total of at least 57 females and 52 males for the non-mated populations. Egg production and hatchability was observed in the offspring at 0 to 2, 2 to 3, 5 to 6 days following their emergence, each day for the 10 to 21 day period, and every 5 days thereafter.

During this experiment a cornmeal-molasses medium was used with Dowicide® solution as a mold inhibitor. As a further precaution all

stock cultures were periodically checked for microsporidian infections (17).

Results and Discussion

The observation that parental age had no effect on the duration of the preimaginal stages of offspring in *Drosophila melanogaster* is consistent with previous work in this species (2, 9). This observation has also been confirmed in the housefly, *Musca domestica* Linnaeus, and the body louse, *Pediculus humanus humanus* Linnaeus (3 16, 4). However, the duration of the preimaginal period was slightly shorter in offspring of *Drosophila* when raised under conditions of constant light as compared to those raised in the dark. On the other hand, in the yellow mealworm, *Tenebrio molitor* Linnaeus, offspring from old parents had a shorter larval life when compared to those obtained from young parents (6, 19). In the milkweed bug, *Oncopeltus fasciatus* (Dallas), offspring obtained from the first and last eggs laid required a longer developmental time than those obtained from eggs laid by middle-aged parents (15).

In Table 1 are shown the number of eggs produced and hatched per female for the mated offspring. The mean values and the standard errors per female are based on the average for each group and the number of groups for each parental age selection. The period of egg production was 46 days for offspring from 0 to 2 day old parents, 56 days for offspring from 2 to 3 day old parents, and 51 days for offspring from parents 30 to 31 days old. The period of egg hatchability was 31 days following eclosion for offspring obtained from the first eggs laid, 51 days for offspring from eggs laid by 2 to 3 day old parents, and 41 days for offspring obtained from old parents. These results are in agreement with preliminary data reported for this species (13). Egg production and hatchability, initially high in all groups, gradually decreased from the 5th day onwards until the 11th to the 13th day of adult life, and then showed an increase until the 12th to the 15th day of adult life, gradually decreasing thereafter. With the exception of egg hatchability for offspring from 30 to 31 day old parents, this increase was significant. Egg production in offspring from 0 to 2 day old parents was consistent with that of the other two groups until the 26th day of adult life, after which except for the 40 to 46 day period there was a significant decrease. On the other hand, although egg hatchability in this selection showed a significant decrease after 18 days, when compared to offspring from 2-3 day old parents and after the 21 days with the exception of the 18-19 and 25-26 day periods, there was no significant difference when compared to offspring from 30-31 day old parents. In general, there was no significant difference in the number of eggs produced per female for offspring from parents 2 to 3 and 30 to 31 days old from the 5th to the 51st day of the egg-laying period, but with the exception of the 25-26 and 40-41 day periods egg hatchability was significantly lower for offspring from 30 to 31 day old parents after the 20th day of adult life. Previous work in *Drosophila melanogaster* has shown that there is a sharp decrease in the number of adult progeny when the female parent is 30 days or older (2). In addition,

TABLE 1

Number of Eggs Produced and Hatched Per Mated Adult Female Fly. Values Are Given With the Standard Errors.

Egg Collection in Days Following Adult Emergence	Offspring From Parents 0 to 2 Days Old			Offspring From Parents 2 to 3 Days Old			Offspring From Parents 30 to 31 Days Old		
	Number of Eggs Produced Per Female	Number of Eggs Hatched Per Female	Percent of Eggs Hatched	Number of Eggs Produced Per Female	Number of Eggs Hatched Per Female	Percent of Eggs Hatched	Number of Eggs Produced Per Female	Number of Eggs Hatched Per Female	Percent of Eggs Hatched
0 to 2	39.1±3.46	37.4±3.67	95.7	28.3±1.28	27.5±1.24	97.2	36.3±1.96	34.2±1.79	94.3
2 to 3	55.9±2.51	54.1±2.51	97.0	48.2±1.03	47.6±1.12	98.8	54.3±2.20	52.7±2.27	97.1
5 to 6	61.6±2.93	55.9±3.19	90.7	54.8±3.18	53.2±3.24	97.1	61.0±1.15	55.2±1.48	90.5
10 to 11	48.4±3.93	43.1±3.40	91.1	40.0±2.79	37.9±3.41	94.8	42.7±2.29	38.7±2.51	90.6
11 to 12	47.3±1.71	42.4±1.70	89.7	49.3±1.78	46.2±1.79	93.7	42.3±2.34	39.2±2.63	92.7
12 to 13	47.4±2.55	40.5±2.55	85.4	49.1±2.78	44.7±2.97	91.0	47.9±2.09	43.1±1.75	90.0
13 to 14	55.3±1.70	47.3±2.66	85.5	43.5±1.93	39.6±1.89	90.8	51.2±2.25	46.0±2.81	89.8
14 to 15	56.3±1.75	47.9±2.64	85.1	45.6±1.77	42.0±1.92	92.1	49.9±2.18	42.8±2.21	85.8
15 to 16	55.3±2.21	42.0±3.10	76.0	44.4±1.37	39.4±1.68	88.8	46.7±2.96	39.6±2.85	84.8
16 to 17	51.4±2.24	36.5±3.05	71.0	42.2±1.63	37.3±1.94	88.4	39.2±2.54	33.0±2.57	84.2
17 to 18	43.8±2.17	32.8±2.53	74.9	42.9±1.92	37.4±1.76	87.2	40.1±1.53	32.3±1.74	85.5
18 to 19	44.5±1.95	22.9±3.50	51.5	39.6±2.45	33.5±2.20	84.6	41.8±1.96	32.4±2.34	77.5
19 to 20	42.3±1.68	19.6±4.13	46.3	39.5±1.68	31.7±1.71	80.3	39.2±1.16	28.0±1.58	71.4
20 to 21	38.2±2.42	16.6±3.16	43.5	37.4±1.93	29.6±2.25	79.1	36.3±1.91	21.7±2.65	59.8
25 to 26	25.3±3.36	3.4±1.27	13.4	26.7±1.54	16.1±1.54	60.3	28.8±2.58	13.1±2.18	45.5
30 to 31	14.8±2.28	3.4±0.91	22.2	23.8±1.47	12.6±2.31	52.9	23.8±2.59	3.3±1.08	13.9
35 to 36	7.8±2.08			21.8±1.21	6.8±1.78	31.2	19.4±3.18	1.6±0.51	8.2
40 to 41	3.5±1.03			10.6±1.15	2.5±0.93	23.6	7.5±2.40	0.9±0.52	12.0
45 to 46	3.7±1.50			9.3±3.95	1.7±0.82	18.3	5.7±2.17		
50 to 51				6.0±2.69	0.4±0.19	6.7	5.8±2.07		
55 to 56				0.6±0.33					

preliminary studies in this species indicate that there is a decrease in the duration of production of adult offspring when both parents are old, but this decrease is not observed if either parent is young (11). The observation that the duration of viable egg production is longer, and that the number of eggs hatched per female is significantly higher after the 26th day of adult life in offspring from parents 2 to 3 days old when compared to those obtained from 30 to 31 day old parents is in agreement with studies on *Musca domestica* where offspring from old parents had a reduced reproductive capacity (3). The increase in egg production and hatchability beginning with the 11th to the 13th day of adult life in the mated groups is consistent with studies on ovarian development and on the increase in the number of adult offspring when the female parent was 15 days old in *Drosophila* (18, 2). However, it must be noted that there was no increase in the percentage of eggs that hatched and that increased reproductive capacity in adults 11 to 13 days old was due only to an increase in the total number of eggs produced.

In Table 2 are shown the number of eggs produced per female for the non-mated offspring. Parental age had no appreciable effect on the duration of egg production, being 56 days for offspring from parents 0 to 2 days old, and 61 days for the other groups. Egg production was significantly higher from the 2nd to the 11th day of adult

TABLE 2

Number of Eggs Produced Per Non-mated Adult Female Fly. Values Are Given With The Standard Errors.

Egg Collection in Days Following Adult Emergence	Offspring From Parents 0 to 2 Days Old	Offspring From Parents 2 to 3 Days Old	Offspring From parents 30 to 31 Days Old
0 to 2	25.9±1.29	20.6±2.51	30.6±3.17
2 to 3	46.3±1.15	29.0±2.48	39.2±3.33
5 to 6	45.9±1.27	32.4±1.91	37.6±3.00
10 to 11	45.0±2.16	27.8±2.30	37.8±2.40
11 to 12	41.0±2.74	30.9±1.00	39.8±2.84
12 to 13	37.9±2.23	35.6±0.74	39.9±2.35
13 to 14	37.2±1.46	36.4±1.36	41.0±2.35
14 to 15	41.0±1.14	36.5±0.91	40.8±2.23
15 to 16	40.9±1.48	35.9±1.06	39.6±3.31
16 to 17	41.0±1.32	37.0±1.80	42.0±2.58
17 to 18	37.2±1.23	36.8±2.14	42.2±2.13
18 to 19	35.9±1.29	36.8±2.03	39.0±2.22
19 to 20	36.9±1.15	36.4±1.33	38.8±2.39
20 to 21	35.6±1.36	35.6±2.03	39.9±2.53
25 to 26	31.5±1.23	27.3±1.19	33.5±2.23
30 to 31	25.8±1.94	21.2±1.32	33.0±2.35
35 to 36	25.2±1.33	20.2±1.79	25.4±1.71
40 to 41	19.8±0.51	17.0±1.25	22.1±1.71
45 to 46	16.1±1.34	12.8±2.46	15.2±1.51
50 to 51	8.6±1.73	12.6±2.02	13.0±1.77
55 to 56	2.3±1.22	10.1±2.55	9.0±2.04
60 to 61		3.5±0.71	1.2±0.78

life for offspring obtained from the first eggs laid and significantly lower after the 51st day of adult life when compared to offspring from parents 2 to 3 and 30 to 31 days old. Egg production was generally significantly higher in offspring from parents 30 to 31 days old until the 12th day and for the period of the 25th to the 45th day of adult life when compared to offspring obtained from 2 to 3 day old parents. Total egg production was highest in non-mated offspring obtained from the first and last selection of eggs and lowest for offspring from parents 2 to 3 days old.

In this study the total number of eggs produced was greater in the mated groups, and was especially pronounced in offspring from young parents when compared to that of the non-mated groups. Also, the number of eggs produced for each observational period was generally significantly higher in the mated groups until the 18th day for offspring from young parents, and until the 15th day of adult life for offspring from old parents. These results are in agreement with observations in the yellow-fever mosquito, *Aedes aegypti* (Linnaeus), where the total number of eggs produced was greater in the mated groups (5).

In Table 3 are shown the number of adult flies and the average survival time for mated and non-mated offspring from parents 0 to 2 and 2 to 3 days old under conditions of constant light and darkness.

TABLE 3

Average Survival Time (days) and Number of the Adult Flies. Values Are Given With the Standard Errors.

	Offspring From parents 0 to 2 Days Old		Offspring from Parents 2 to 3 Days Old	
	Mated	Non-Mated	Mated	Non-Mated
	Raised Under Conditions of Continual Darkness			
Male	43.1±1.05	41.5±1.40	43.8±1.65	39.2±1.15
N	68	52	71	62
Female	42.5±1.60	46.4±1.05	40.8±1.77	47.7±1.51
N	69	75	52	63
Total	42.8±0.71	44.4±0.88	42.6±1.21	43.5±0.95
N	137	127	123	125
	Raised Under Conditions of Continual Light			
Male	32.9±1.05	35.4±1.42	33.0±1.33	36.2±1.43
N	63	65	55	82
Female	38.6±1.47	43.4±1.53	39.6±1.54	44.4±1.18
N	56	57	60	78
Total	35.6±0.89	39.2±0.72	36.4±0.94	40.2±0.90
N	119	122	115	160

There was no significant difference in the survivals of mated and non-mated offspring obtained from parents 0 to 2 or 2 to 3 days of age for both groups, but as would be expected, offspring raised under conditions of constant light had a shorter life span than those raised in the dark. In general, the survivals of mated and non-mated male and female offspring from young parents raised under conditions of constant

darkness were not significantly different from previously reported work (10).

The fact that selection of the first eggs may have detrimental effects on the offspring was observed in the human body louse, *Pediculus humanus humanus*, where the strains obtained from eggs laid during the first and second days of oviposition died out during the first or second generation, whereas eggs selected during the third and fourth days of oviposition yielded successive generations for the duration of the experiment, these parental age effects being more pronounced at lower temperatures. However, the reproductive capacity was not significantly affected by parental age in this species (4).

Previous studies on offspring from young and old parents in *Tenebrio molitor* have lead to the conclusion that activating ions and enzyme activity may be associated with nutrition and thus responsible for parental age effects (8), Observations reported for *Drosophila melanogaster* and the confused flour beetle, *Tribolium confusum* Jacquelin duVal, have indicated a relationship between phosphatase activity and egg production in the aging female (1, 14). Further studies in *Tenebrio* have shown a greater decrease in methionine in beetles from old parents, when compared to those from young parents, as they aged (7). Similar studies have shown that the cystine-cysteine complex was present only in homogenates of third- and fourth-instar larvae obtained from young parents in this species (20). It has been suggested that these sulfur amino acids may function in the tying up of free radicals and thus retard aging processes. Preliminary studies in *Drosophila melanogaster* have shown histological differences in the corpora allata cells of third-instar larvae obtained from young and old parents (12). This finding leads to the conclusion that a more subtle humoral influence may be involved in the effects of parental age on the offspring.

Summary

The effect of parental age on egg production and hatchability of continually mated and non-mated offspring in *Drosophila melanogaster* (Oregon-R strain) was observed. Continually mated offspring from 2 to 3 day old parents had the longest period of egg production and hatchability when compared to continually mated offspring from parents 0 to 2 and 30 to 31 days old. In this case the offspring obtained from the first egg selection had the greatest variability and the poorest performance. The secondary rise in fecundity observed in 11 to 13 day old adults was due solely to an increase in the number of eggs produced. Parental age had no pronounced effect on the duration of the egg-laying period in non-mated offspring, but egg production was highest in offspring obtained from the first and last selection of eggs. However, total egg production was higher in the mated groups when compared to that of the non-mated groups, this effect being more pronounced in offspring from young parents. There was no significant difference in the survivals of offspring obtained from parents 0 to 2 or 2 to 3 days of age. In general, although continually mated offspring obtained from the first eggs laid had a poorer performance as regards egg production and hatchability when compared to those obtained

from eggs laid 24 hours later, this selection had no effect on the survivals between these two groups.

Literature Cited

1. Butz, A. 1963. Effects of aging on acid and alkaline phosphates content in **Drosophila melanogaster.** Bull. Entomol. Soc. Amer. **9**:165.
2. ————————, and P. Hayden. 1962. The effects of age of male and female parents on the life cycle of **Drosophila melanogaster.** Ann. Entmol. Soc. Amer. **55**:617-618.
3. Callahan, R. F. 1962. Effects of parental age on the life cycle of the house fly. **Musca domestica** Linnaeus. Jour. New York Entomol. Soc. **60**:150-158.
4. Flemings, M. B., and D. Ludwig. 1964. Effects of temperature and parental age on the life cycle of the body louse, **Pediculus humanus humanus.** Am. Entomol. Soc. Amer. **57**:560-563.
5. Liles, J. N., and D. M. DeLong. 1960. The longevity and productivity of adult male and female **Aedes aegypti** when reared separately and together on three different diete. Ann. Entomol. Soc. Amer. **53**:277-280.
6. Ludwig, D. 1956. Effects of temperature and parental age on the life cycle of the mealworm, **Tenebrio molitor** Linnaeus (Coleoptera, Tenebrionidae). Ann. Entomol. Soc. Amer. **49**:12-15.
7. ————————, and C. R. Jones, 1963. Changes in the concentration of certain amino acids in homogenates of the yellow mealworm, **Tenebrio molitor,** during aging. Ann. Entomol. Soc. Amer. **57**:210-213.
8. ————————, C. Fiore, and C. R. Jones. 1962. Physiological comparisons between offspring of the yellow mealworm. **Tenebrio molitor,** obtained from young and from old parents. Ann. Entomol. Soc. Amer. **55**:439-442.
9. O'Brian, D. 1961. Effects of parental age on the life cycle of **Drosophila melanogaster.** Ann. Entomol. Soc. Amer. **54**:412-416.
10. ————————. 1962. The effect of parental age on the duration of life of mated and non-mated progeny in **Drosophila melanogaster.** Proc. Ind. Acad. Sci. **72**:344-347.
11. ————————. unpublished data.
12. ————————., and R. Grillo. unpublished data.
13. ————————, C. Yablonsky, and C. Gillooly. 1964. Parental Age effects on egg production and hatchability in offspring of **Drosophila melanogaster.** Amer. Zool. **4**:331.
14. Raychaudhuri, A. 1963. Changes in acid and alkaline phosphatase content of aging male and female **Tribolium confusum.** Bull. Entomol. Soc. Amer. **9**:165.
15. Richards, A., and M. Kolderie. 1957. Variation in weight, developmental rate, and hatching of **Oncopeltus** eggs as a function of the mother's age. Entomol. News. **68**:57-64.
16. Rockstein, M. 1957. Longevity of male and female house flies. Jour. Gerontol. **12**: 253-256.
17. Stalker, H. D., and H. L. Carson. 1963. A very serious parasite of laboratory **Drosophila.** Dropsophila Inform. Ser. **38**:96.
18. Stolfi, J. E. 1938. Ovarian development in **Drosophila melanogaster.** M. S. thesis, New York University.
19. Tracey, Sr., K. M. 1958. Effects of parental age on the life cycle of the mealworm, **Tenebrio molitor** Linnaeus. Ann. Entomol. Soc. Amer. **51**:429-432.
20. ————————, S. Jakowska, and S. Nolan. 1958. Parental age and free amino acids in larvae of **Tenebrio molitor.** Anat. Rec. **132**:513-514.

The Distribution of Macro-Invertebrates in Littoral Macrophytes in a Northern Indiana Lake

RUTH E. PETTEE and CAMERON E. GIFFORD, Earlham College

Introduction

This study of the macroscopic invertebrate organisms which live in association with macrophytes, in the littoral zone of Dewart Lake (Indiana; Kosciusco County), is limited to the following seven aquatic plants: *Chara* species, *Potamogeton amplifolius, Nymphaea adorata, Elodea canadensis, Myriophyllum exalbescens,* and *Megalodonta Beckii.* These plants were chosen because of their variety in leaf exposure to the surface, amount of leaf dissection, denseness of plants in the average bed, and typical water depth.

It has been hypothesized by Gerking (1957) that the greater the leaf dissection the greater the variety in the animal population. The investigator realized that plants grow in different densities and have different surface area per length of stem.

Procedure

Exact quantitative sampling could not be done. However, since consistent methods and random collecting were used, the results should give a relative measure of the abundance of the phytomacrofauna. Organisms embedded in stems of macrophytes (such as several of the midge larvae) and those in association with roots and bottom mud are disregarded in this study.

At each collection, the habitat, water depth, and time of day were noted. Samples were taken from relatively pure beds of the plant studied, and plants collected were cut off above the roots. The collection procedure was to collect with a dipnet the surface insects seen at the site, obtain a random quantity of water from among the plants, and collect a random number of plants. Collections were made between July 10-July 27, 1964. Both time of day and water depth were varied for collections of each plant.

For analysis the water from each site was poured into a white enamel pan and the live macroscopic organisms were carefully picked out. The macroscopic invertebrates (this excludes Ostracoda, Copepoda, Cladocera, and some small Turbellaria) were identified to family and counted for each sample, with some specimens being preserved.

Results

The data showed that the majority of invertebrate groups studied appeared to form fairly constant percentages of the total macrofauna in association with a specific plant. The exceptions, which varied greatly among the different specimens of the same plant, were: Naiadidae on *Potamogeton natans* and *Megalodonta;* Trichoptera on *Chara* and *Elodea;* Tendipedidae on *Nymphaea* and *Potamogeton natans;* and Coenagrionidae on *Nymphaea.*

It was found that Elodea had the greatest percentage of total organisms and showed the greatest variety of invertebrates (22 of

the 29 groups studied), while *Potamogeton amplifolius* showed the least variety (14 groups). Figures 1 and 2 present a summary of results. The most numerous invertegrates were Diptera (primarily Tendipediate larvae) followed closely by Amphipoda. Some groups were significantly abundant on one plant and seldom occurred on another, such as: Planariidae (24.3% on *Potamogeton amplifolius;* 1% on *Chara*); and Amphipoda (47.9% on *Chara;* 3.9% on *Nymphaea*).

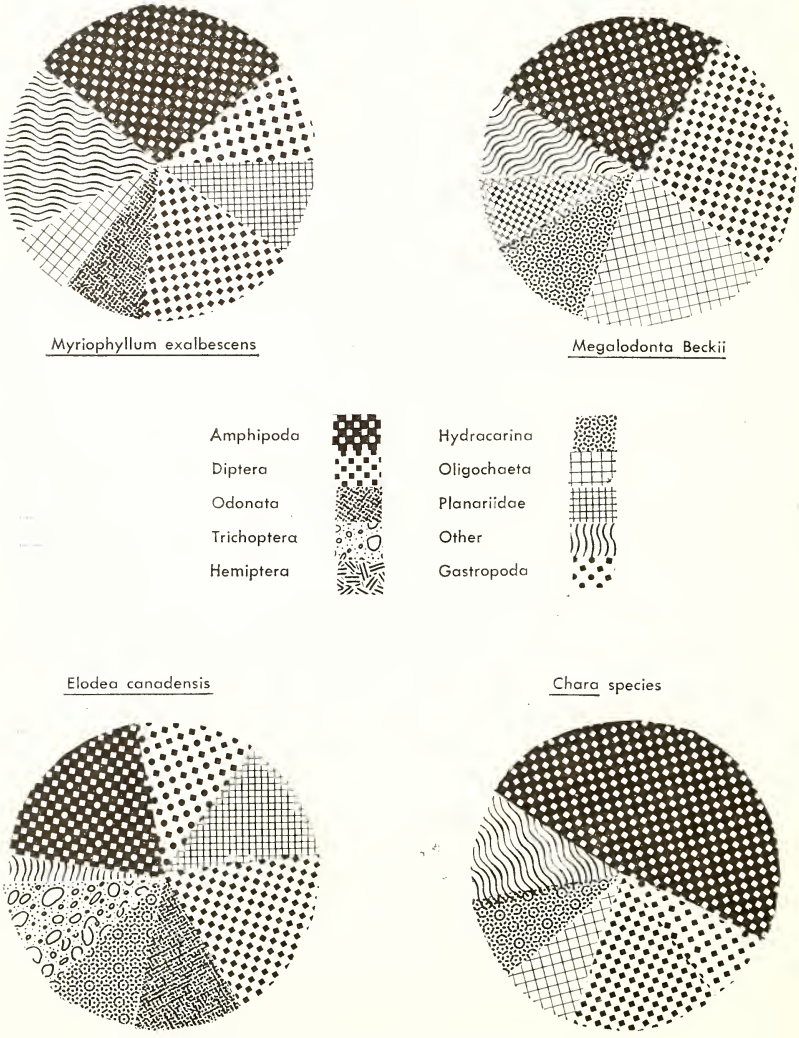


Fig. 1. Sector graphs showing animal abundance among 4 plants.

Discussion

It is interesting to speculate the reason for occurrence of particular groups on certain plants. This occurrence may be related to

plant form and function, as well as with known food and protective habits of the animals. Gastropoda—found primarily on *Myriophyllum, Elodea, P. natans,* and *P. amplifolius.* The leaves of these plants would provide ample support for the snail's attachment, while those of plants such as *Chara* would not. In addition, there may be a correlation be-

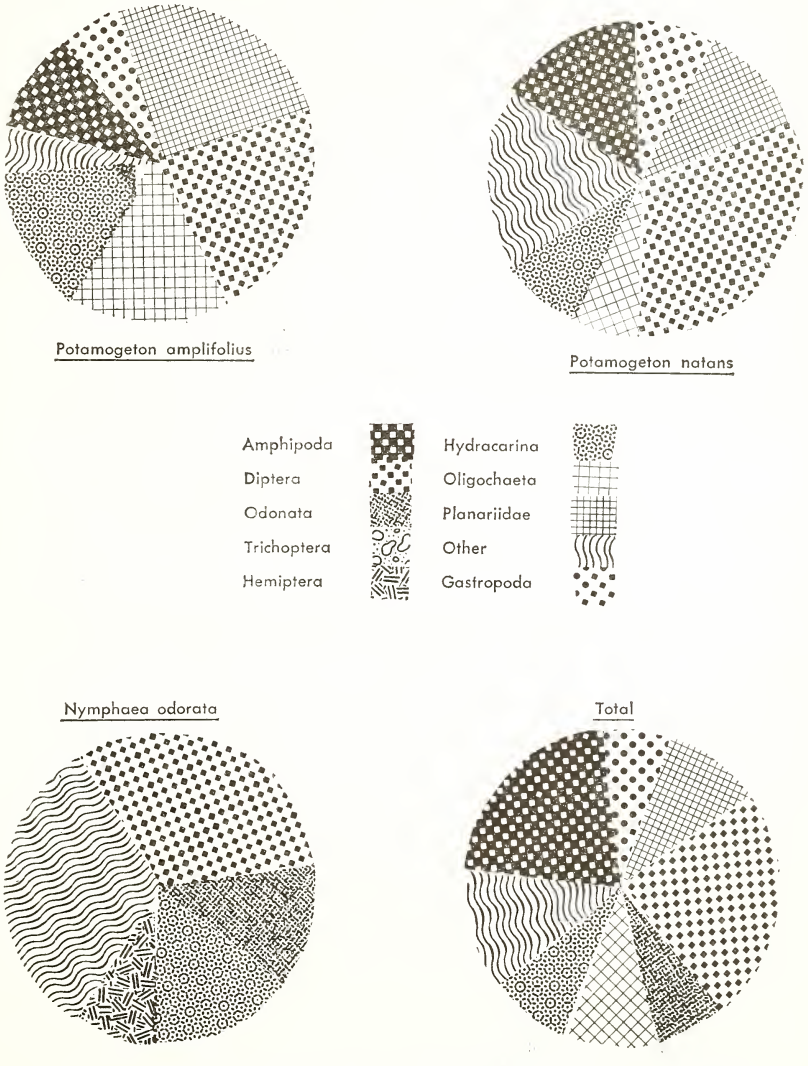


Fig. 2. Sector graphs showing animal abundance among 3 plants, and total.

tween the presence of a film of blue-green algae on these plants and the abundance of Gastropoda. This algae is the primary constituent of the snail's diet. Diptera—found primarily on *Megalodonta; Potamogeton natans,* and especially *Nymphaea.* Aside from the *Megalodonta,* this

prevalence might be explained by the requirement of the larvae to obtain most of their air by breaking the surface with their spiracles. Living in a patch of floating leaves would be advantageous. One Tabanidae larva (which typically would be buried in mud) was found, in *Chara*, a plant anchored in shallow water.

Coleoptera—found primarily on *P. natans* and *Nymphaea*, plants with floating leaves. The adults depend on atmospheric air and carry a film or layer of air on the wings while underwater.

Trichoptera—found significantly on *Elodea* and, to a lesser extent, on *Megalodonta* and *Myriophyllum*. Caddis fly larvae require a substrate for building a case as they grow.

Hemiptera—found primarily on *Nymphaea*, also on *Myriophyllum* and *Potamogeton natans*. The families represented skim about on the surface substrate. The Pleidae, which are known to swim in tangled vegetation, were found only in *Myriophyllum* and *Megalodonta*.

Odontata—found primarily on *Nymphaea, Myriophyllum*, and *Elodea*. A large number of empty cases from the nymphal instars were found on *Nymphaea* leaves and *Myriophyllum* fruits above the surface. These plants had an abundance also of small Gastropoda, Trichoptera, and Diptera, which make up the main diet of Odonata nymphs.

Ephemeroptera—found primarily on *Myriophyllum* and *Nymphaea*. Mayfly nymphs are vegetarian, and the families found are climbing, rather than burrowing, forms. The data gives no other correlation with the known habits of the order.

Hydracarina—found primarily on *Nymphaea, P. amplifolius*, and *Megalondonta*. The water mites rely upon the substrata, and if they swim far away they will eventually fall to the bottom. Since the nymphal stages parasitize both aquatic nymphs and flying forms, they are near the surface.

Amphipoda—*Chara* had by the far the largest percentage of this group, which were present significantly on all the plants except *Nymphaea*. Amphipods feed on debris of organic matter in *Chara* beds is dicates that the high concentration of organic mater in *Chara* beds is favorable. Amphipods react negatively to light, by hiding in the vegetation and their fusiform body shape may be an adaption for protection in greatly divided vegetation. Since *Nymphaea, P. amplifolius*, and *P. natans* have the smallest percentage, it appears that the Amphipods prefer a plant with dissected leaves.

Hirundinea—*P. amplifolius* had a small but significant quantity of leeches; the other plants had little if any. Leeches require a firm subtrate and hide during daylight, and were rarely found on plants with dissected leaves.

Oligochaeta—*Megalodonta* had the largest percentage of aquatic worms, and *Elodea* the smallest. Oligochaetes are thought to be specific to temperatures and organic pollution. They may survive in low concentrations of oxygen.

Planariidae—*P. amplifolius* and *Elodea* were leading in *Planaria*, and *Chara* had practically none. Planarians which respire through the body wall, require high concentrations of oxygen.

Hydra—The few found were primarily on *Elodea*. Hydrozoans are

carnivorous, feeding mainly on Cladocerans, Copepods, Insects, and annelids. *Elodea* had the greatest variety in organisms, and this may affect the presence of Hydras.

Conclusions

Although correlations between the invertebrate macrofauna distribution and their known habits can be made, no fast conclusions can be drawn. One of the most interesting observations, the fact that Amphipods comprise 50% of the *Chara macrofauna*, cannot be explained at this time.

This study has shown that invertebrate groups tend to have a fairly constant distribution on specific plants. In further work, it would be significant to study the invertebrate distribution in areas of different dissolved oxygen and calcium carbonate concentrations, of different temperatures, and of nature of the lake bottom. The macrofauna of a particular plant could be studied in plots of varying denseness and varying water depth. Another significant addition would be a controlled study of the time of collection and the variety of distribution found. In any such work a technique to achieve constant methods of collection would be pre-requisite.

Literature Cited

1. Borror, Donald J., and Dwight M. Delong, 1964. An Introduction to the Study of Insects.
2. Gerking, Shelby, 1957. A Method of Sampling the Littoral Macrofauna and its Application. Ecology **28(2)**.
3. Pennak, Robert W., 1953. Fresh-Water Invertebrates of the United States.
4. Peterson, Alvah, 1959. Larvae of Insects.

Scar: A Temperature Sensitive Mutation in Tribolium castaneaum Herbst

HAROLD EDDLEMAN, Purdue University

In 1959 the author and a group of students at Salem-Washington Township High School undertook the isolation and characterization of mutants of *Tribolium castaneum* Herbst which would be useful as markers in irradiation, genetic, and ecological competition studies. One of the mutants isolated has been named scar *(Sc)*. This paper describes the scar mutant, presents data on its mode of inheritance, and reports the effect of temperature on penetrance of the mutant phenotype. Professor A. E. Bell, Purdue University, who first noted that temperature affected penetrance of the mutation, generously provided supplies and space for the studies reported here.

Materials and Methods

Purdue Foundation A served as the wild type in all crosses and was the strain from which the mutant was isolated.

The scar *(Sc)* mutant was isolated from the third inbred generation of x-irradiated (3,000 r.) wild type imagoes. The mutant is characterized by a depression in the metasturnum just anterior to the coxa (Fig. 1B). The surface of the affected area is rough and is delimited anteriorly by a fold. The mutant phenotype is visible in pupae several hours before eclosion.

Culture medium consisted of 95 parts sifted whole wheat flour and 5 parts brewers yeast. Relative humidity was 65 ± 5%.

Temperature shift experiments involved collecting heterozygous eggs, at one day intervals, at 27° C and allowing development to continue at this temperature until a specified age at which time they were transferred to 37° C for completion of the life cycle. Similar down-shift experiments were also performed (from 37° to 27°).

Results and Discussion

There being no evidence of sex-linkage, the results from reciprocal matings have been pooled and are presented in Table 1. Each of the percentages reported in Table I is the median from 1 to 5 separate experiments totaling 500 to 2000 beetles, but there were significant variations between certain replicates. One-degree fluctuations in temperature could account for the observed variations. In view of the probability of temperature variations within this range, the data of Table I are qualitative rather than quantitative.

Dominance and expressivity of the scar mutant is complicated by the effect of temperature on its penetrance (Table 1). Among homozygotes, one finds phenotypes ranging from typical scars on both sides (Fig. 1B), through single scars (Fig. 1C), to reduced scars (Fig. 1D) and even wild types. Thus, expressivity is variable and penetrance is incomplete. Since heterozygotes *(Sc/+)* have the same range of phenotypes as the homozygotes *(Sc/Sc)* without a new intermediate phenotype being present, the scar mutant is dominant over its wild type allele. Since penetrance of the mutant phenotype varies from zero at

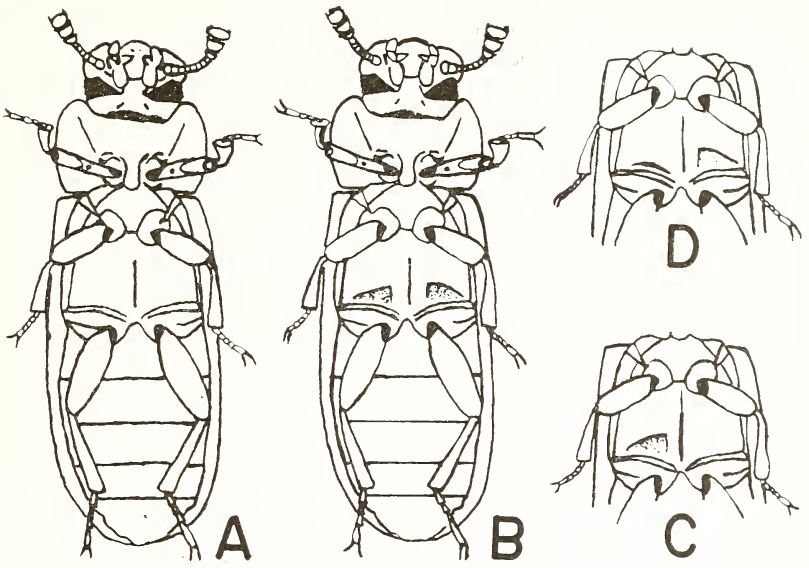


Figure 1. A is the wild type. B is the common scar phenotype. C and D are variations in expressitivity of scar and constitute about one-fifth of the scar phenotypes.

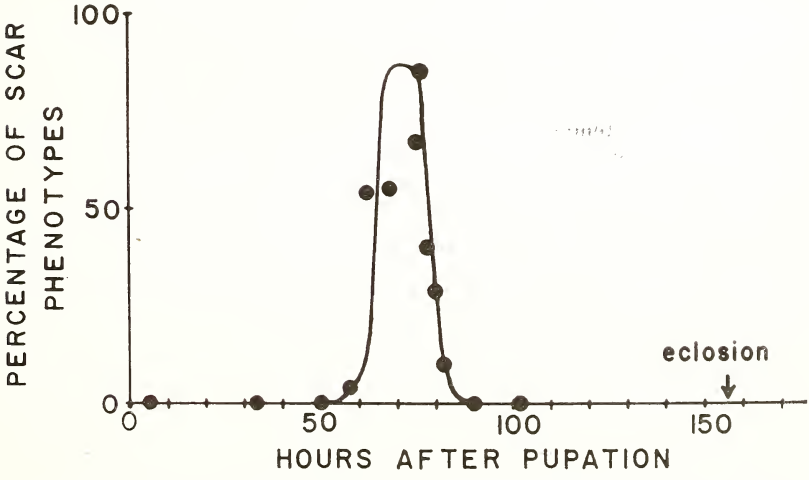


Figure 2. Pupae, collected at 2-hour intervals, were held at 27° except during a 10-hour exposure to 37° C. Penetrance of the scar phenotype is plotted against the median pupal age at the midpoint of the exposure to 37° C.

27° C. to 100% in some experiments at 37° C. (Mating B, Table 1), scar will be a useful marker only at temperatures approaching the lethal limit for the species.

The results of Mating C (Table 1) show that a second outcross to wild type does not appreciably reduce penetrance of the scar mutation

—this indicates that the scar phenotype is controlled by a single gene. On the other hand, the results of single pair inbreeding experiments suggest that other genes affect penetrance of the scar phenotype; however, quantitative data in support of this hypothesis are not presently available.

Temperature shift experiments which tested each day of the life cycle showed that penetrance of the scar phenotype in heterozygotes depended solely upon the temperature during the middle portion of the pupation period. Thus, pupae held at 37° during the middle portion of the pupation period develop scar phenotypes, but pupae of similar age held at 27° developed no scar phenotypes regardless of the temperature during the larval and early pupal or late pupal stadia.

The duration of the temperature sensitive period was determined by means of temperature pulse experiments. Pupae, collected at 27° at 2-hour intervals, where held at 27° until they had reached various post-pupation ages and were then transferred to 37° for ten hours and then returned to 27° until eclosion. The results are presented in Fig. 2. The percentage of scar phenotypes observed in each sample, consisting of 20 to 50 individuals, is plotted against median pupal age at the midpoint of the exposure to 37°. The plot shows that the midpoint of the temperature sensitive period is 71 hours after pupation at 27° and that the temperature sensitive period spans approximately one-fifth of the pupal stadium.

To investigate whether shorter exposures at 37° would result in scar phenotypes, 135 pupae, collected at 27° over a 6-hour period, were divided into two lots. One lot was exposed to 37° for 6 hours

Table 1
Effect of temperature on matings of the scar mutant

Mating	Percentage of scar phenotypes among progeny at various temperatures (°C)			
	37°	35°	33°	27°
A. *Sc*/*Sc* x *Sc*/*Sc*	N.T.	95	73	N.T.
B. *Sc*/*Sc* x +/+	96	69	9	0
C. *Sc*/+ x +/+	N.T.	33	2	0
D. +/+ x +/+	N.T.	1	0	0

N.T. = not tested

at the median post-pupation age of 71 hours and 46% developed the scar phenotype. The other lot was similarly exposed for 3 hours and 8% of these developed the scar phenotype. Thus, longer exposures to 37° resulted in greater penetrance but this observation may involve two factors. Firstly, the effect of temperature during the sensitive period may be accumulative. Secondly, there are variations in the developmental age of individuals within a sample, and the greater penetrance at longer exposures to 37° may be the result of higher percentages of individuals maturing into the temperature sensitive period during the exposure.

It is not likely that the scar mutation was induced by x-rays because scar phenotypes are occasionally observed when the wild type stock is incubated at 35°. However the frequency of the scar gene in the wild type stock is not great enough to invalidate the qualitative data presented in Table 1.

The temperature sensitivity of the scar mutant may be due to temperature sensitivity of the synthesis of a mutant protein or other substance or due to instability of a previously formed protein at high temperature. It would be interesting to determine whether the defect in morphological development of the mutant is coincident with or preceded by the period of temperature sensitivity.

Summary

The scar *(Sc)* mutation of *Tribolium castaneum* Herbst involves a a depression in the metasternum just anterior to the coxa. One or both sides may be affected. Penetrance of the mutation in heterozygotes varies from zero at 27° C to 100% in some matings at 37° C and depends solely upon the temperature during the central one-fifth of the pupal period. The mutant phenotype is visible in pupae several hours before eclosion.

INSTRUCTIONS FOR CONTRIBUTORS

Eligibility

Papers

Indiana Academy of Science members in good standing are eligible to submit papers for publication in the **Proceedings.** When a paper is signed by more than one author, all must be members in good standing. Preferably, eligibility should be established before submitting the papers, as such papers are given priority. In any case all authors must be certified by the Treasurer for payment of dues and old reprint bills at the time of the deadline (see below). Papers reaching the editor after the deadline are ineligible. All papers must be accompanied by an abstract in the form specified below, marked "for the editor" unless one has been sent in earlier.

Only papers which have been presented in person at the meeting can be accepted. To keep the volume within the budget, the editor usually must return the longer manuscripts, printing only the abstract. Well-prepared manuscripts will be given priority.

Abstracts

If the Divisional Chairman puts a paper on his program for the Fall Meeting, the abstract will be printed in the **Proceedings** regardless of the author's membership status, unless the paper is published in full.

One typed **original** of each abstract, marked "for the editor" may be submitted to the Divisional Chairman at the time of the meeting or it may be mailed directly to the editor. This should be ready with the minium of editing for publication; i.e., in the standard abstract form (see a **Proceedings** abstract) and double spaced; it should not include directions to the chairman regarding time, lantern, etc. The latter information may be added to a copy marked "for the Divisional Chairman" and sent to him. The editor **cannot** accept **carbon copies** of abstracts. The length of an abstract should not exceed **200 words.** Many of the items listed below for the preparation of papers apply for abstracts.

Deadline at the Editorial Office

Whether sent via the Divisional Chairman as prescribed, or directly, all material to be considered for publication in the **Proceedings** must reach the editor within **20 days** following the Fall Meeting.

Preparation of Manuscripts

A. **Refer to current copy of the Proceedings for the accepted style of abstracts and papers, and follow this, especially in literature citations, headings and footnotes.**

B. Type on 11 x 8½ inch bond paper with a new ribbon, leaving some margin. **Double-space everything,** including title, author's name and institution, footnotes, quotations, legends and literature list. The original will become the printer's copy; if it must be retyped it will be sent back to the author for this.

C. Footnotes should be kept to an absolute minimum. Necessary footnotes should be numbered consecutively throughout; asterisks are not used. Acknowledgments may be placed only in the introduction or in a footnote.

D. Literature citations should not occur in footnotes, but should be in an **alphabetized** list at the end of the paper, headed **"Literature Cited."** The highly abbreviated form used by the chemists has **not** been adopted for the **Proceedings.** Follow this model:
7. Doe, J. B. and R. C. Roe. 1949. New light from old radioactive carbon. Jour. Am. Biological Soc. **34**:273-305.

E. Only initial letters or the words in titles, headings and table headings should be capitalized.

F. Do not underline anything except scientific names, in headings or elsewhere.

G. All literature listed and all tables and illustrations should be **referred to** in the text.

H. Tables, which are costly to print, should be reduced to a minimum. Avoid small tables scattered through the text. Each table should be typed on a separate letter-size sheet and placed at end of paper. Outsize tables cannot be accepted.

I. Photographs should be printed on glossy paper and have good contrast. It is best to mount them trimmed to fit tightly together at the edges in groups, on stiff cardboard with rubber cement. **Proportion** the group for a full page of the **Proceedings**, or use the full width of the page (4⅛") and any part of the page's height. Do not mix line drawings and photographs in the same group. **Legends** should be on a separate letter-size sheet, numbered to correspond and placed at end of paper.

J. The originals for line drawings need be no more than twice the size desired for the printed figure. They should be **proportioned** and **arranged** to fit the page size of the **Proceedings.** The lettering should be carefully done and of suitable size to allow for necessary reduction. Do not submit printed maps when the necessary reduction will efface the narrower lines or render some of the lettering hardly legible; such maps should be redrawn and lettered in adequate size letters, omitting unnecessary details. The use of a carbon ink on a heavy white paper or other suitable surface reproduces well. The typewritten label does not reproduce well.

K. New authors, especially, are reminded that a scientific paper should summarize the work, not recapitulate it. It must be much more concise than a university thesis, avoiding all extraneous material, especially long tables and lists of little interest except to the author.

L. Major professors are urged to **review** all papers by their graduate students, for both form and content, before they are sent in for publication. Of those based on university theses, manuscripts carrying the approval by the professor will be given preference over those without approval. Work by undergraduates is seldom, if ever, suitable.

M. The summary should be complete and clear in itself, and not over 4 percent of the length of the paper. For very short papers no summary is necessary.

N. **Reprints** of papers are paid for by authors, at cost. Directions for ordering accompany the galley proof and the orders are placed at the time the author returns the corrected galley proof to the editor. **Abstracts** are not reprinted.

O. The editor needs, at the time he mails out galley, **current addresses** for all coauthors of all abstracts and papers. Many former graduate students lose the opportunity to order reprints when there are faulty forwarding addresses. It is suggested that the student's permanent home address be written on the reverse side of that abstract copy marked "for the editor."

Selection of Papers

Every year a few more papers are submitted than can be published with available funds. Therefore, not all papers received can be included in the **Proceedings.** Manuscripts prepared concisely, in the style recommended above, will receive first consideration. Authors should not expect to publish very long papers in the **Proceedings.** Among papers of primarily regional interest, e.g., in certain aspects of botany, zoology, geology, geography and anthropology, those dealing with Indiana material will be accorded preference.

The selection of papers for the **Proceedings** is the responsibility of the Editorial Committee.

INDEX

Abnaki Indians, social organization, 112.
Aerobic heavy sludge digestion, 149.
Alfalfa weevil, 207.
Algae, blue-green, 165.
Algonkian Indians, 112.
Alman, D. H., 294.
Archaeology, 72.
Archaeology: Archaic, 87, 114.
Archaeology, climatic change and the Northern Plains Archaic, 99.
Archaeology, Illinois, 81.
Archaeology, Indiana, 90.

Barr, D. J., 259.
Barzynski, H. F., 180.
Beecher, A. B., Necrology, 41.
Benzene mixtures, radiolysis, 180.
Bieber, C. L., 268.
Biology Dept., Purdue, 284.
Bird Eggs Gorby collection, 348.
Black, G. A., Necrology, 42.
Blind snakes, 350.
Blue Island, Illinois, 232.
Bram, R. A., 207.
Brigadier, W., 205.
Brock, J. E., Necrology, 45.
Burkhardt, R. W., Jr., 195.
Burns, J. T., 348.
Burton, M., 179, 180, 181.

Cantin, A. J., 245.
Cartersburg till, end moraines, 223.
Castilleja coccinea, 314.
Cat stomach, 360.
Chandler, Leland, 197.
Chapman, Florence, 84.
Chicks, 362.
Christian, J. E., 339, 343.
Clark's Grant, land-survey divisions, 248.
Cleveland, J. H., 271.
Cleveland, M. L., 219.
Climatic change and the Northern Plains Archaic, 99.
Climatic records, A comparison of, 245.
Coal Mine Reclamation Problems, 255.
Colchicine-induced cells, virus growth in, 118.
Cold exposure, larval amphibian, 351.
Color preference, chick, 362.
Cook, D. J., 183.
Corals, Mississippian, of West-Central Indiana, 268.
Crania in demonstrating racial relationships, 72.
Culture of planktonic blue-green algae, 165.

D'Allessio, J., 181.
Dialkyl quinolines, preparation, 183.
Diffusion coefficients, electroanalytical measurements of, 178.
Dillon, M. A., 179.
Dinocardium robustum, 319.
Disc electrode configurations in electroanalytical diffusion, 178.
Drosophila, effects of age of parents, 356.

Early Woodland, Greene County, 90.
Eberly, W. R., 165.
Eddleman, H. L., 398.
Edington, W., Necrology, 41.
Engineering geology, 259.
Eurycea bislineata and *Eurycea lucifuga*, 348.
Excitation transfer, 179.

Ferris, J. M., 189.
Fish distribution, Putnam Co., 353.
Fletcher, R. I., 149.
Follicle stimulating hormone chicken pituitary, 351.
Forests, old-growth, analyses, 169, 307, 308.
Fourier Synthesizers, 294.
Frisch, J. A., 112.
Fruit Insect Cultures, 219.

Gammon, J. A., 353.
Germfree and conventional chickens, antigens, 120.
Germfree mice, 125.
Gillooly, C., 386.
Girton, R. E., 284.
Gould, G. E., 196.
Graphical analysis of forests, 169, 307.
Green, R. J., 140.
Groundwater geology, 259.
Guernsey, L., 255.
Guernsey, C. W., 335.
Gunther, W. C., 362.
Gussin, E. S., 350.

Hackett, C. F., 298.
Haenisch, E. L., 60.
Halteria grandinella, 351.
Hamon, J. H., 348, 360.
Hart, J. F., 224.
Hassler, C. R., 149.
Hentz, R. R., 180.
Herley, P. J., 179.
Hess, E. B., 278.
Hoffer, G. N., Necrology, 46.
Hook, J. C., 245.
Hopewell culture, 81.

Hosseinie, S. O., 195.
Hughes, H. K., 294, 298.
Hunter, K. B., 81.
Hurt, W. R., 99.
Hymenoptera, 197.
Hypera postica (Gyll.), 194.

Indiana's population needs, 230.
Insects, economic, in 1964, 207.
Iron Sulfide in sphalerites, Mississippi Valley, 271.

Japanese beetle, 196.
Johns, R. M., Necrology, 41.
Junior Academy, 33.

Knotweed (Polygonum), 307.
Kornicker, L. S., 348.

Lair, B., 232.
Land-survey divisions, noncongressional, 248.
Lindsey, A. A., 169, 307.
List, J. C., 350.
Lithostrotionella, West-central Indiana, 268.
Ludwig, P. K., 179, 181.
Luminescence, 179.
Lymphocytopoiesis and plasmacytopoiesis, 125.

Mackell, J. F., Necrology, 50.
Macklin, J. M., 194.
Malecite Indians, social organization, 112.
Manufactural geography of Blue Island, Illinois, 232.
Mapping by means of corals, 268.
Marks, G. C., 314.
McBee, E. T., 179.
Mertens, T. R., 307.
Metamorphic stasis in larval amphibia, 351.
Meyer, A. H., 232.
Michigan road land sections, 248.
Micmac Indians, social organization, 112.
Micronucleated cells, virus growth in, 118.
Miller, M. S., 195.
Mitchell, A. C. G., Necrology, 52.
Montgomery, R. H., 325.
Moraine near Crawfordsville, 223.
Moraine near Knightstown, 223.
Morton, C. J., 179.
Mossbauer experiments, 298.

Necrology, 41.
Neumann, G. K., 90.
Neumann, H. W., 87.
Newman, J. E., 343.
Nomenclature in archaeology, 114.

O'Brian, D., 386.
Olson, G. B., 120, 125.
Osmun, J. V., 207.
Owen, D. E., 222.
Osteoarthritis in three aboriginal populations, 84.
Overpopulation of Indiana, 230.

Paintbrush, Indian, 314.
Paleopathology, 87.
Parents age effects on offspring in Drosophila, 386.
Passamaquoddy Indians, social organization, 112.
Pecking frequency, chick, 362.
Penobscot Indians, social organization, 112.
Petty, R., 308.
Physical anthropology, 68, 72, 81, 84.
Phytoplankton, laboratory culture, 165.
Plethodons, 375.
Plinthite on Maui Island, Hawaii, 335.
Poliomyelitis virus, 136.
Polistes spp., 197.
Polygonum, 307.
Polyoma virus, 132.
Population concentration in Indiana, 224.
Population increases vs. prosperity, 230.
Powell, H. M., 132, 136.
Powell, R. L. 222.
Pottery, Early Woodland, 90.
Povinelli, R. J., 179.
Pratylenchus penetrans, 195.
Precipitation, Indiana, gross gamma radioactivity in, 343.
Presidential address, 60.
Pre-training, chicks, 362.
Protura of Wayne County, 205.
Psorophora ciliata (Fabricius), biology of, 194.
Psorophora discolor (Coquillett), occurrence of, 195.
Purdue Biology, 284.

Radioactivity, gross gamma, in Indiana precipitation, 343.
Radioactivity of Indiana soils, 339.
Reclamation problems, strip coal mine, 255.
Resonance transfer in viscous media, 179.
Reynolds, A. E., 375.
Reynolds, W. A., 351.
Rhykerd, C. L., 343.

Sacrum of the American Indian, 68.
Schaal, L. A., 343.
Schelwalt, W. E., 183.
Schmelz, D. V., 169, 307.
Schneider, A. F., 248.
Schropulariaceae, 314.
Scintillation counting, 339.
Sexual differences in crania, 72.
Siverly, R. E., 194, 195.
Skeletons from the Klunk Site, Calhoun County, 81.
Sludge digestion, aerobic heavy, 149.
Smail, J. K., 72.

Smut, loose, 155.
Social Organization of Northeastern Algonkians, 112.
Social Wasps in Indiana, 197.
Soil associations, Perry County, 328.
Soils, gross gamma radioactivity of, 339.
Soil survey, Lake County, 325.
Stabler, T. A., 375.
Statolon, 132.
Strip coal mine reclamation, 255.
Swartz, B. K., Jr., 114.

Tamar, H., 349.
Temperature effect, chick, 362.
Tomak, C. H., 90.
Trehaleses in insects, 350.
Tribolium, temperature mutant, 398.
Urbont, A. L., 68.
Uv light pulse, 181.

Vespa spp., 197.
Vespidae, 197.
Vespula spp., 197.
Vincennes, land-survey divisions, 248.
Visher, S. S., 230.

Ward, G. L., 205.
Wayne, W. J., 223.
Wenner, K. A., 325.
West, T. R., 259.
Williczko, T. B., 179.
Wise, C. D., 348.
Wisconsin population distribution, 278.
Wostmann, B. S., 120, 125.
Wyatt, G. R., 350.

Yablonsky, C., 386.
Yunker, T. G., Necrology, 55.

Zeller, F. J., 351.
Ziemer, P. L., 339, 343.
Zimmerman, J. F., 178.